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安泰信电子测量仪器 ATTEN PRODUCTS

• 频谱分析仪	• Spectrum Analyzer
• 射频微波器件	• RF & Microwave Components
• 信号源	• Signal Generator
• 频率计	• Frequency Counter
• 示波器	• Oscilloscope
• 直流稳压电源	• Regulated DC Power Supply
• 交流稳压电源	• Regulated AC Power Supply
• 直流开关电源	• Switching Power Supply
• 逆变电源	• Power Inverter
• 衰减器	• Attenuator
• 放大器	• Amplifier
• 850热风拔放台	• 850 Rework Station
• 电焊台	• Soldering Station

经销商 FRANCHISER

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ATTEN®
INSTRUMENTS

CE

AT5005/AT5006

SPECTRUM ANALYZERS

安泰信® 频谱分析仪

User's Manual 中英文使用说明书

AT5005/AT5006

SPECTRUM ANALYZERS

安泰信频谱分析仪

感谢您选择本公司产品，在使用本仪器之前，
请仔细阅读本手册。
Thanks for using our products,
please read this manual thoroughly before operation.

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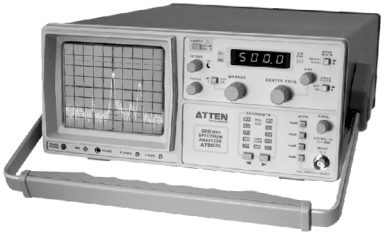
频谱分析仪（AT5005/5006）



AT5005

- 频率范围：0.15~500MHz
- 4位半数字显示
  （中心和标记频率，0.1MHz分辨率）
- －100～+13dBm幅度范围，20kHz, 400kHz中频带宽和视频滤波器
- 跟踪发生器（仅对AT5006）
- 频率范围：0.15~500MHz
- 输出电压：+1~－50dBm（50Ω）
- 整机包装配件：说明书一本，电源线一根。

AT5000系列频谱分析仪频率超出1GHz（0.15~1050MHz）有粗调和细调调节中心频率，加上100kHz/格~100MHz/格扫频宽度选择，组成简易的频域测量。一个4位半LED显示可选为中心频率或标记频率读数。AT5011装有跟踪发生器。本仪器适用于产品开发时的先期测试，在交第三方正式测试之前，一组近场探头AZ530适用于初样机电路板和原样机阶段，对电缆和印制板等处的发射“热点”测试和电磁兼容性水平评估。

用 途

- 安泰信频谱分析仪可以很好的对遥控器、对讲机、测量发射接收机、无绳电话、有线电视CATV及通讯机等有线、无线系统进行检查及信号频率的分析比较。
- 安泰信频谱分析仪可以检测手机射频电路的本振信号，中频信号、发射信号等。用AT5000系列频谱分析仪检修手机不入网故障点，十分快捷和准确。
- 频谱分析仪通常显示没有处理过的原信号的信息，电压、功率、周期、波形、边带和频率。
- 频谱分析仪常用的测量有：谱波失真，双音交调失真和杂波探测。
- 电磁兼容测试（EMC）：测量各种电子设备上发射的有害电磁波的功能。另从PHOTE（耳机）插孔还可以输出AM/FM检波信号，可用来识别噪声施加影响的广播信号，从认证的角度上来说，先进行放射噪声的测量对事前的评定、研究是非常有效的测量功能。
- 还可广泛用应于教学、科研。安泰信频谱分析仪能真正看到电信号（如射频脉冲信号）用傅利叶级数展开出来的图象，教学上更容易理解，科研上更清楚。

技术指标

频率范围	0.15~500MHz
中心频率显示精度	±100kHz
标记精度	±0.1%频宽+100kHz
频率分辨率	100kHz（4 .5位LED）
扫频精度	±10%
频率稳定度	优于150kHz/小时
中频带宽（–3dB）	400kHz和 20kHz
视频滤波器（开）	4kHz
扫描速率	43Hz
幅度范围	–100~+13dBm
屏幕幅度显示范围	80dB（10dB/格）
参考电平	–27dBm~+13dBm（每级10dB）
电平精度	±2dB
平均噪声电平	–90dBm（20kHz带宽，典型值－99dBm）
失真	2次3次谐波＜–55dBc 3阶交调：–70dBc （二个信号相隔＞3MHz）
灵敏度	优于－90dBm
对数刻度真实度	±2dB(不加衰减) 250MHz
输入衰减器	0～40dB（4×10dB）
输入衰减精度	±1dB/10dB
最小损毁电平	+10dBm ± 25VDC (衰减0dB) +20dBm (衰减40dB)
扫频宽度	100kHz/格~100MHz/格，1－2－5分档和0Hz/格（0扫描）

跟踪发生器

- 输出频率 0.15MHz ~ 500MHz
- 输出衰减器 0 ~ 40dB（4 × 10dB)
- 输出衰减精度 ± 1dB
- 频率响应 ± 1.5dB
- 输出阻抗 50Ω（BNC）
- 射频干扰（RFI） < 20dBc
- 输出电平 – 50 ~ +1dBm（10dB 步进和可变调节）

通用指标

- 显示 6寸CRT, 8 × 10分格内刻度
- 轨迹旋转 面板调节
- 电源 220V ± 10%, 50Hz~60Hz
- 功耗 约20W
- 工作环境 0~40℃
- 保护 安全I 级（IEC1010 – 1）
- 重量 约 7 Kg
- 尺寸 380 × 285 × 125（L × W × H） mm
- 输入阻抗 50Ω
- 插座 BNC
- 负载阻抗 > 8Ω
- AM/FM解调输出

AZ530近场嗅觉探头系列（选配）

（仅对1GHz频谱分析仪）

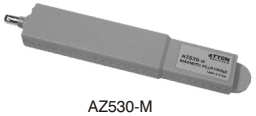
AZ530是探测射频电磁场的理想工具包。在产品发展阶段，交于第三方进行测试之前，它是电磁干扰预认证测试的不可缺少手段。全套包括3个手持探头，其内装有前置放大器，可用频率范围从100kHz到超过1000MHz。这些探头包括1个磁场探头，1个电场探头和1个高阻抗探头，都与频谱仪或射频接收机的50Ω输入阻抗相匹配。其供电可用电池，镍镉电池或通过电源线从频谱仪送来。信号送出是通过1.5米BNC电缆。当与频谱仪或测量接收机连用时，探头可以找出或划定电磁干扰源，同样可评估电路板和样机电磁兼容问题。帮助使用者估计发射场以及加屏蔽后的性能比较。也可进行对电缆和组件的机械屏蔽性能和兼容性测试。

技术指标

- 频率范围 0.1 ~ 1000MHz（更低的频率极限取决于探头）
- 输出阻抗 50Ω
- 插座 BNC
- 输入电容 2pF（高阻抗探头）
- 最大输入电平 +10dBm (依赖频率范围)
- 直流输入电压 20Vmax
- 供电 6VDC，4节AA电池，频谱仪供电
- 供电电流 8mA（磁场探头）
5mA（电场探头）
24mA（高阻抗探头）
- 探头尺寸 195 × 40 × 19（L × W × H） mm
- 外壳 塑料（内部电屏蔽）

磁场近场探头（M）

它向连接的仪器输出一个与射频磁场强度成比例的电压。利用这个探头，电路的高频源可安排得彼此很靠近。磁场强度是随电源距离的立方成反比。距离增加 1 倍，则场强为原处的1/8（H = 1/d3，式中 d 是距离）。

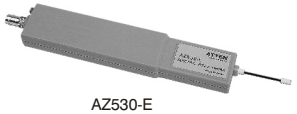


AZ530-M

实际应用时，当干扰源出现时，探头的输出电压会迅速增加。当制作电路板时就可以很明显的测出哪些（例如IC）造成了干扰。从频谱仪上可以看出这干扰最大幅度的频率在哪里。这样，就可采取措施改进以达到电磁兼容方面的要求。效果很明显。亦可研究“泄漏”区域的屏蔽，以及电缆、电线传输中的干扰泄漏。

电场单极探头（E）

E场单极探头在3种探头中有最高的灵敏度。它的高灵敏度足以做为无线电或电视接收的有源天线。用了它，整块电路板或设备所发散出的电场强度都可以被测到。例如，可以用于确定屏蔽的有效性、测量滤波器的有效性，用测量设备通过电缆输出而顺电源产生的射频干扰对整个全发射的影响。此外，E场探头在鉴定测试中也可做相对测量。这样它可实施纠正性压缩（干扰）后测量，以便再提交鉴定时得以确认。这样，经过了预认定（鉴定前）测试后，在正式鉴定测试时就不必惊慌了。



AZ530-E

高阻抗探头（H）

高阻抗探头（Hi–Z）可以测量个别接点或印制板线路板的射频干扰（RFI）。它是直接接触式探头。它的阻抗很高（接近印制板的绝缘电阻）以及电容仅2pF（1GHz时80Ω）。所以可以接触上去而不影响电路的（不很大影响）关系。所以可以对线路板上个别点加以测试。例如：可以定量地测量滤波器或其它隔阻性电路。个别的IC脚可认为是射频干扰之源。通过这个高阻探头，至电路的测量点，探头的输出是低阻抗可联接至频谱仪的50Ω输入端。

AZ530-H

一般说明

AT5000系列频谱仪操作容易。合理的各调节器布置使得每个人都会很快熟悉它的操作。然而，即使有经验的使用者也应预先阅读说明书以了解全部功能。开箱后，检查有否机械损伤和零部件松动。若发现运输损伤，则必须立即通知供货方。该仪器不能使用。

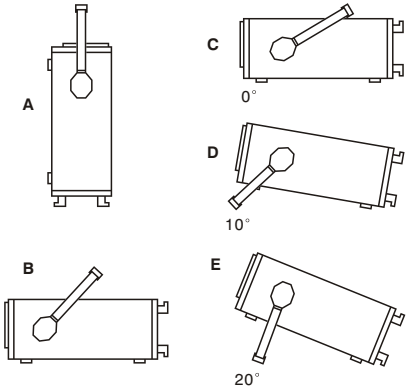
符号

注意——参阅说明书

危险——高电压

保护接地（大地）端子

存放



为使观察屏幕方便，有三种（C、D、E）仪器角度放置供参考。在搬运后若就地上放置，参阅（A）。若放在水平地方，参（C）。若10° 角如D位置，则提手应移向下方到自动锁住。若要E方向，则从D位置拉出两边提手再移下去直到再锁住。提手将向B图位置时锁住则可实现水平移动。同时，仪器必须被提起，否则提手会跳回。

安全性

本仪器经设计与测试符合“IEC出版物10101，对测量,控制和实验用途的电气设备的安全性要求”。CENELEC规则EN61010-1代表这个标准，表示离厂的安全条件。本册中列述了使用者必须遵循的重要信息和警告以便保证安全地操作以及使频谱仪处于安全使用条件。机身罩盖和所有测量端子都与保护地点相连，该点与电源的地是相通的。本仪器工作是按照Ⅰ类安全性规定（三芯电源线其中一芯是保护地和一个有地触点的插头）。电源／供电线插头只许插到有保护地触点的外电源插座。若用了没有保护地连接线的接线，则必须加上保护接地连接措施。在进行测量连接之前必须先插好电源线。接地的金属可触及部份（机箱、插座、接头）和电源的过电点（火线、中线）之间经过2200VDC的绝缘击穿性试验。在某些条件下，由于和其它市电工作的设备或仪器连接测量时在测量的显示中或耳机收听的声音中可能有50/60Hz交流哼声电压。这可用一只隔离变压器（Ⅱ类安全性要求的）在市电电源插座与被测设备插头之间。大多数阴极射线管会放射出X光。但是，本仪器的福射量远底于最大允许值36pA/Kg（0.5mR/h）。

当保护（地）有失联时，仪器将处于不能使用状态，当不打算使用时应作安全措施。如发生以下现象时，仪器可能发生了保护接地问题：

- 有可见的损坏
- 测量时有失常表现
- 在不良环境下长期贮存后（即在户外或潮湿条件）
- 受强烈运输压力下（包装不好）时。

使用条件

本仪器设计为室内使用。允许使用环境温度范围为+10℃ (+50° F) ~+40℃ (+104° F)。偶然也可以+10℃ (+50° F) ~ – 10℃ (+14° F) 间使用而不会减低其安全性。允许的运输及贮存温度范围为 – 40℃ (– 40° F) ~ + 70℃ (+ 158° F)。最大使用高度为2200m（不工作15000m）。最大的相对湿度为80%。

在仪器出现凝结水的条件下，则在通电使用前应该让它先和环境同化。在某些情况时（例如频谱仪温度非常低时）应该在通电使用前让它恢复2个小时。仪器应当在干净和干燥的房间内，不具爆炸危险，腐蚀性，灰尘和潮湿的场合使用。频谱仪可工作在任意位置，但不应阻挡对流冷却。连续不断工作时仪器应当水平位置放，更可取的是稍向上由提手支起。

指标所列误差仅当环境温度+15℃ (+59° F) 和+30℃ (+86° F) 之间并且经60分钟预热后才有效。不算误差的值对各仪器是平均起来看的典型数值。

产品保证

ATTEN对它制造和销售的产品提供材料和制造缺陷上的1年免费保证。此保证不适合由于不适当使用或不合适的维护和保持造成的失效，缺陷或损坏，ATTEN将不被约束去提供服务。即使在本保证条件下去修理，如这些损坏是由于非ATTEN人员对产品进行安装，使用维修，服务或改装造成，亦要适当收取材料费。

为得到本保证的服务，顾客应接触和知会销售此产品的分销者。

每台仪器在离开生产间前都经过10个小时的老化并经质量检测。用此法可实际上剔出早期失效。在经邮运，铁路或集装运后建议保存它的包装。本保证不包含运输损坏和粗动作造成的损坏。

在有毛病时，须将看到的主要毛病写于一张标签上，贴在机箱上。若此时同时将名字和电话号码也写上（地区和电话号，或直到部门），这样可以加速处理对保证的要求。

维护

频谱仪的各个重要性能应定期地进行仔细的检验。只有通过这样才能极大保证所有显示的信号具有技术数据为基础的精度。

仪器外表应定期用灰尘刷子清扫。机箱和提手，塑件和铝件上难清除的污垢可用打湿的布（99%水+1%中性清洁剂）擦除。酒精或洗涤用汽油（石油醚）可用来去除油污。屏幕可用水或者洗涤汽油（不能用乙醇（酒精）或溶剂），之后必须用一块干的干净的无绒布擦揩。不能让清洁液漏入仪器内部。使用其它的清洁物件会伤及塑料件和涂层表面。

供电电压

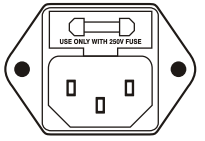
频谱仪工作在供电电压220V AC。

保险丝座是在3极电源插座的上方，保险丝盖很容易拆下的。保险丝座可以通过用一个小起子压它的支架而脱开。支架是在保险丝座的左右两侧，它必须向中间推压直到两端都卡住。保险丝可更换。

绕上保险丝或短路保险器座都是不允许的；ATEEN对这样做造成的后果不负任何责任，并且所有的保证将变为零和无效。

保险丝型号：φ5 × 20mm；250V AC

- 应符合IEC标准127，第四种（或DIN41662或41571，第三种）
- 时间特性：**慢爆**
- 供电电压：220V ± 10%
- 额定保险丝电流：T315mA
- 额定电流：T160mA



概述

本频谱仪可以检出频率范围为0.15到500MHz内电气信号的频谱分量。被检测的信号和它的组成必须是周期性的。相对于工作在Yt模式的示波器，示波器是在时域上显示幅度，频谱分析仪是幅度在频域上的显示（Yf）。“一个信号”的各频谱分量，在频谱仪，将被观察到。而示波器上的显示同样信号将看到1个波形。

频谱仪实际上是一个3次变频的超外差式扫频接收机。被测信号 ($f_{入}$ = 0.15 ~ 500MHz) 加到第一混频器，在这里它与一个压控振荡器 ($f_{本振}$ = 1350 ~2350MHz) 来的信号电压混频。这个振荡器称作第一本振（本地振荡器）。这振荡器和输入频率之差（$f_{本} - f_{入}$=第1中频）为第1中频，它通过调谐在1350MHz上的带通滤波器。然后进入放大器，然后再经过2级混频器和放大器。第2中频是29.875MHz，第3中频是2.75MHz。在第3中频级中，在到幅度解调器之前，先选择性地通过1个400kHz或者是20kHz的带通滤波器。视频信号对数输出可以直接，或者通过1个低通滤波器，送到Y轴放大器。该放大器输出连到CRT的Y偏转板。

X偏转是由斜波发生器电压所驱动。此电压还和一个直流电压合成后去控制第1本振。频谱仪扫描的频率范围取决于斜波的高度。扫频由扫频宽度调节按键控制。在0扫频宽度模式时，只有直流电压去控制第1本振。

AT5006还装有跟踪发生器。它提供一个频率范围为0.15~500MHz的正弦电压。跟踪发生器的频率决定于频谱仪部份的第1本振。频谱仪的（输入频率）和跟踪发生器的（输出频率）是同步的（一样）。

使用说明

在操作AT5000系列颁谱仪之前，先阅读本手册中“安全性”这一段很重要。使用AT5000系列颁谱仪时不需要特别的知识。直观的面板操作件和基本功能的制约保证立即可以有效地使用。但为了

保证最佳工作，须要遵守一些基本指示。

注 意!

AT5000系列频谱仪最灵敏的元件是输入部份。它包括信号衰减器和第1混频器。未经输入衰减时，加到输入端的电压必须不超出+10dBm（0.7Vrms）AC或±25VDC。
当有40dB最大衰减时，AC电压必须不超出+20dBm（2.2Vrms）。
这些极限必须不被超出，否则，输入衰减器和/或者第1混频器可被损坏。
当经过LISN（线路阻抗指定化网络）测量时，频谱仪的输入必须用一个瞬变限幅器来保护。

在测量心中没有数的信号之前，应检查有没有不可接受的高电压。也推荐开始测量时用最大的衰减量和最宽的扫频范围（500MHz）。使用者也应该考虑有否频率范围以外(例如1200MHz)的超高信号幅度可能出现，虽然它看不到。0Hz～150kHz频率范围内在AT5005/5006频谱仪中是没有指标的。若此范围出现显示，则幅度是不准确的。避免将显示调得过亮。在频谱仪上显示的各信号一般都可容易的读出，即使在低亮度情况。

由于变频原理，在0Hz上会出现一根谱线。称为中频直通。这是由于第1本振扫过中频而致。它可因不同仪器而有不同的高度。满屏幕还超出并不说明仪器有故障。

操作旋钮（按钮）

前面板图（见最后一页）中各个号码说明如下。

（1）聚焦

光点锐度调节。

（2）亮度

光点亮暗调节。

（3）电源（通ON和断OFF）

当电源打到通处，约经10秒钟将有光束出现。

（4）轨迹旋转

即使有磁性（铍镍合金）屏蔽，地球磁场对水平扫描线的影响仍不可能避免。通过一个内装的电位器可用来调整它，使水平扫描线与水平刻度线基本对齐。

（5）标记—通ON/断OFF

当标记按钮置于OFF (断) 位置时，中心频率 (CF) 指示器发亮，此时显示器读出的是中心频率。当此开关在ON (通) 位置时，标记 (MK) 指示器发亮，此时显示器读出的是标记的频率。该标记在屏幕上是一个尖峰。标记频率可用标记（MARKER）旋钮来调节，它可重合到一根谱线上。

在进行正确幅度读数前应将标记断掉。

（6）中心频率/标记 (CF /MK)

当数字显示读中心频率时中心频率指示器亮。中心频率是指示波管上水平线的中心处的频率。当标记按钮在通时（ON），标记指示器亮。此时显示器读出标记处的频率。

（7）数字显示器 (中心频率/标记频率之一读出)

7段。100kHz分辨率。

（8）校准失效

此LED闪亮时表示幅度值不正确。这是由于扫频宽度和滤波器的配合、中频滤波器设置不当而造成幅度降低的读出。这种情况可能出现在扫频范围过大相对于中频带宽（20kHz），或者视频滤波器带宽（4kHz）时。若要正确测量，可以不用视频滤波器或者减小扫频宽度。

（9）中心频率—粗 /细调

二个旋钮都用于调节中心频率。中心频率是指显示在屏幕水平中心处的频率。

（10）（中频）带宽

选择中频带宽在400kHz或20kHz。选在20kHz带宽时，噪声电平降低，选择性提高，能分隔开频率更近的谱线。此时，若扫频宽度过宽时，由于需要更长的扫描时间（做不到）而造成信号过渡过程产生的降低信号幅度而使测量不正确。“不校准”LED发亮就指出了这个条件。

（11）视频滤波器

视频滤波器可用来降低屏幕上的噪声。它使得正常下在平均噪声电平上或刚好高出它的信号（小信号）的谱线得以观察。该滤波器带宽是4kHz。

（12）Y位移

调节射速垂直方向移动。

（13）输入

频谱仪的BNC 50Ω输入。在不用输入衰减时，不允许超出的最大允许输入电压为±25VDC和+10dBmAC。当加上40dB最大输入衰减时最大输入电压为+20dBm。

（14）衰减器

输入衰减器包括有4个10dB衰减器，在进入第1混频器之前降低信号幅度。按键压下时每个衰减器接入。衰减器选择，参考电平和基线电平（噪声电平）三者的配合有如下面所列：

衰减器	参考电平（顶线）	基线（底线）
0dB	–27dBm 10mV	–107dBm
10dB	–17dBm 31.6mV	–97dBm
20dB	–7dBm 0.1V	–87dBm
30dB	+3dBm 316mV	–77dBm
40dB	+13dBm 1V	–67dBm

参考电平由上端水平刻度代表。最下面的水平刻度线为基线。垂直刻度分成每10dB一格。前面已指出过，不能超出最大允许输入电压。这点极端重要，尤其当屏幕只显示输入信号的一部份时。因为，输入信号可能在屏幕显示看到的以外还有超过的电平存在，从而损坏输入衰减器和/或第1混频器。请同时参阅“输入”。

在连接任何信号到输入端之前，先选择设置为最高衰减量(4×10dB)和最高可用频宽(扫频宽度50MHz/格)。若此时将中心频率调在250MHz，则在最大可测和显示频率范围内检测出任意谱线。当衰减器减小时基线向上移动，则可指出在最大可显示频率范围（例如1200MHz）之外有超过的幅度。

（15）扫频宽度 < > 按键

“扫频宽度”选择按键用来调节水平轴的每格扫频宽度。用>按键来增加每格频宽，用<按键来减少每格频宽。转换是1–2–5步级，从100kHz/格到500MHz/格。此扫频宽度以MHz/格显示出，它代表水平线每格刻度。中心频率是指水平轴中心垂直刻线处的频率。假如中心频率和扫频宽度设置正确，X轴有10分格的长度。当扫频宽度低于100MHz时，只有全频率范围的一部份可被显示。当扫频宽度设在500MHz/格位置和中心频率设在250MHz时，显示频率以每格50MHz扩展到右边，最右是500MHz [250MHz + (5 × 500MHz)]。同样，中心向左边则频率减低。此情况下左边的刻线代表0Hz。这时，可以看到1根特别的谱线即“0频率”。这是由于第1本地振荡器频率通过了第1中频而产生的。当中心频率相对于扫频宽度较低时有此现象。“0频率”的幅度对每台频谱仪是不一样的。它不能当参考电平来使用。显示在“0频率点”左边的那些谱线被称为镜频。在“0扫频”模式时，频谱仪工作在像是一台可选择（中频）带宽的接收机。此时频率的选择是通过“中心频率”旋钮。通过中频滤波器的频谱线产生一个电平显示（选频表功能）。

所选的扫频宽度/格值在设置按键上方的LED显示出来。

（16）X（频率）—位置校零

（17）（频率）线性调校

重要事项!

这些调节事项是仅仅在仪器校准时才动它们。在正常使用下它们不要求调节。当需要对它们实施调节时，需要用一台很精确的射频信号源。

（18）耳机

（3.5mm耳机插孔）

阻抗大于16Ω的耳机或扬声器可以连到这个输出插座。当频谱仪对某一个谱线调谐好时可能有的音频会被解调出来。这是通过中频部份的调幅解调器实现的。它解调了任何调幅信号，也可提供(滤波器)单边调频信号的解调。输出有短路保护。

（19）音量

调节耳机输出的音量。

（20）探头供电

输出+6V DC电压以使AZ530近场嗅觉探头工作。此电源专为它们用，其专用线随AZ530提供。

（21）电平（仅用于AT5006）

用此旋钮可以连续调节跟踪发生器输出电平11dB范围（输出衰减器0衰减时 –10～+1dBm）。

（22）跟踪发生器（仅AT5006有）

若按钮压下时（ON）跟踪发生器工作。此时从输出插座BNC座输出正弦波信号，它的频率决定于频谱分析仪。在“0扫频”模式时输出的即是中心频率。

（23）输出（仅对AT5006）

50Ω插座用于跟踪发生器。输出电平在+1～–50 dBm范围内可调节。

（24）衰减器（仅对AT5006）

输出电平衰减器由4个10dB衰减器组成，可使信号在去到“输出”插座前经过衰减。
所有4个衰减器都相等，可用各别按钮操作。这样，可容易得到所需要的衰减量，例如：20dB衰减值。

垂直幅度校准

在校准之前保证各输入衰减在不衰减位置，信号频谱线峰顶达到最高的一条水平刻线位置时，此信号幅度为–27dBm，每下一格减10dBm。如果40dB衰减器全部按下，此时最高水平刻度线幅度为+13dBm（–27dBm+40dBm）。

在进行校准之前，将各输入衰减器（14）不衰减。在校准之前仪器必须至少有60分钟时间预热。将**“视频滤波器”**（11）置于断（OFF）。**“带宽”**（10）置于400kHz以及**“扫频宽度”**（15）在2MHz/格。

将电平为–27dBm ± 0.2dB（10mV）的射频信号接到频谱仪输入端（13）。此信号频率应在2MHz到250MHz之间。调节中心频率到信号频率上。

A：在屏幕上出现一根–27dBm单谱线。调节**“Y位置”**（12）将频谱线顶调到最上刻线位置。所有输入衰减器都不衰减。
下列调整是当上述目的不能达到时维修目的而做。仪器内部的XY印制板上有Y–AMPL（**幅度**）调节。在需要调节此垂直幅度时，请参阅维修说明内容。

B：下一步，信号源的信号多次来回调节其输出电平在–27dBm与–77dBm之间，调节**“Y–幅度”**控制使谱线峰在屏幕上一变动5格。若因此而改变了Y位置，则返回重复A节内容。重复A与B内容使达到理想要求。最后，输入衰减器（14）在–27dBm电平上进行测试。将输入衰减器打上，每10dB谱线在屏幕上下移一格，全部打上下移4格。全部衰减都加上时误差不应超出 ± 1dB。

水平频率校准

在校准之前保证各输入衰减器（14）在不衰减位置。在进行校准之前AT5005/06必须至少预热60分钟时间。**“视频滤波器”**按钮（11）应当置于**OFF（断）**位置，**“带宽”**（10）必须在400kHz，以及**“扫频宽度”**（15）设在100MHz/格。在将中心频率调到250MHz后，将一个标准信号加到输入端。其输出电平应在噪声上高出40到50dB。

C：将信号源频率调到250MHz，将250MHz信号峰，用水平位置（X–POS）旋钮（16）将它对准屏幕水平的中心点。

D：将信号源调到100MHz输出。若该100MHz谱线不在左起第3格线，则用“X–AMPL”（水平幅度）（17）调整它。需要时重复C步骤以使二者都正确。重复调整到满意。

介绍频谱分析仪

电气信号分析对许多工程师和科学家来说是一个基本的问题。即使问题不是电气的，也依靠传感器将信号转换成电信号再分析其感兴趣的参数。各种的物理量变换到电气信号后，有多种仪器可对它们进行时间和频率二种领域的分析。

传统观察电气信号是用一台示波器在时域内观察。时域是针对电信号的特性：恢复时间和相位上的关系。然而，并非所有电路的特性都可用时间域来完全表征。电路元件，如放大器，振荡器，混频器，调制器，检波器和滤波器，最好的表征其特性的是频响数据。用频率域来观察可得最好结果。为测量频域就需要鉴别出各频率组成并可对各频率分量电平读数的仪器。仪器之一就是频谱仪。它能在示波管屏幕上用图显示相对于频率的电压或功率。

在时域里，信号的所有频率分量都总合在一起。在频域范围，复合信号的各频率都分隔开，并且每个频率的功率电平都被显示出来。频域即是相对于频率的幅度的图示。频域包含了时域不能表示的信息，所以频谱仪比起示波器来说有某些优点。

频谱仪比起示波器来讲对低电平的失真具有更高的灵敏性。正弦波可从示波器上看到（时域），但是在频域里，可以看到其谐波失真。高的灵敏度和宽的动态范围也使频谱仪得以测量低电平调制。可测量调幅，调频和脉冲调制的射频信号。频谱仪可以测量载波频率，调制频率，调制电平，和调制失真。也可测量变频器件的特性，如变频损耗、隔离度和失真度，从显示上即可读出。

频谱仪可用来测量长期和短期频率稳定度。诸如，振荡器的噪声边带，剩余调频和预热时间内的频率漂移都可通过频谱仪的已校准频宽被测得。连同频谱仪扫频测量可测量滤波器或放大器的扫频响应。只要用跟踪发生器就可简单实现。

频谱仪的分类

频谱仪有二类，扫描调谐式和实时型频谱仪。扫描调谐频谱仪用电扫描在频率范围内调谐。因此，频谱的频率分量是随着时间依次采样出来。所以，可以显示周期信号和随机信号，但不能测量显示瞬变响应。实时频谱仪顾各思义可同时显示在其测量范围内的信号各分量的幅度。这保持了信号的时间属性以致可以显示出相位信号信息。实时频谱仪可以显示瞬变响应，也可显示周期和随机的信号。

扫描调谐式频谱仪通常有调谐射频或者超外差型。调谐射频（trf）频谱仪是用一个中心频率可调的调谐带通滤波器对所希望的频率范围扫调，检波器于是在示波管上输出垂直偏转，水平扫描发生器一方面扫滤波器，另一方面输出到示波管的水平偏转板去。这是一种简单，不贵的频谱仪，具有宽的频率范围，但分辨率和灵敏度却不好。由于trf频谱仪是扫描滤波器,它们受制于扫描宽度因而制约频率范围（通常小于10倍频率范围）。分辨率取决于滤波器带宽，而带宽又往往随频率而变。

最常用的频谱仪与trf 频谱的的不同点在于前者是扫描一个固定带宽的带通滤波器而不是像后者的扫描带通滤波器去选择信号频率。这就是一台窄带接收机，通过锯齿电压去压控本地振荡器频率，从而，对被测信号进行电子调谐。同样锯齿电压被加到示波管的水平偏转板。而接收机的输出是同步地加到示波管的垂直偏转板，于是一幅幅度相对于频率的图被显示出来。

频谱仪对其测量频率范围的调谐是通过改变本振的调谐电压而实现的。本振与输入信号进行混频得到中频，再被检波出来和偏转显示。当输入信号与本振的频率差等于中频时，此时频谱仪上出现一根响应频谱线。超外差技术的优点是得到了高灵敏度（由于中放），所以除了可以看到信号的基波之外还可以看到信号的多次谐波。

同样，改变中频滤波器的带宽，就可以改变分辨率。当然，超外差频谱仪不是实时的，并且它的扫描速率必须考虑到中频滤波器的时间常数。示

波管左边出现的一个谱线峰有时叫作“0频率指示”或“本振直通”。当频谱仪扫过0频率时，本振信号直接通过中频，而在示波管上产生峰线，即使没有外信号输入也然。（0信号调谐，即本振频率 = 中频滤波器中心频率）。它影响了频谱仪测量的低端极限。

频谱分析仪的要求

为了在频谱仪上精确显示信号的频率和幅度，频谱仪必须经专门校准，满足许多要求：

- 宽的调谐范围
- 宽的频率显示范围
- 稳定度
- 分辨率
- 平坦的频率响应
- 高的灵敏度
- 低的内部失真

频率的测量

频率刻度有3种不同扫频模式：全频段，每格扫频宽度和0扫频。全频段扫频模式有最宽的频率范围显示，以最快捕捉信号。（不是所有种类的频谱仪都能提供这个模式）。每格扫频宽度是用来对特定信号加以拉近观察。在每格模式时，显示的中心频率由调谐旋钮所控制，而刻度系数是由频宽或扫频宽度控制来设定。0扫频时，频谱仪如同一台带宽可选择的固定调谐接收机。

绝对值频率测量通常由频谱仪调谐度盘上测得。相对频率测量就要求线性的扫频。从测量屏幕上2个信号的相对间隔，就得到它们的频率差。

频谱仪应比被测信号更稳定是很重要的。频谱仪的稳定性取决于它的本地振荡器。稳定性可用短期的或长期的来表示。剩余调频是短期稳定度的一个指标，以Hz峰峰表示。短期稳定度也可表示为噪声边带，它表征了频谱仪的频谱纯度。噪声边带的表示是距载频若干Hz处，以规定的中频带宽，列出低于载频的dB数值。长期稳定度即是频谱仪本振的频率漂移。频率漂移是指在某一规定时间段内频率变了多少值（例如：Hz/分钟，或Hz/小时）。

分辨率

信号频率在频谱仪能被测量之前它应该先被分隔出来。分隔意味着信号与最近一根分开。频谱仪的分辨率决定于它的中频带宽。中频带宽通常定义为中频滤波器的3dB带宽。无线电接收机的60dB带宽（Hz）对3dB带宽（Hz）之比称为矩形系数。更小的矩形系数，表示频谱仪更大可能分辨出不相等幅度的相邻很近的信号。若矩形系数是15:1，则相差60dB的两个信号必需有7.5倍中频带宽的相隔频率才能分隔测出。否则频谱仪只显示1个信号。

分辨出2个不等幅靠得很近的信号的能力，不单单决定于频谱仪的中频滤波器的矩形系数，噪声边带也能降低其分辨能力。它们出现在中频滤波器的斜边上，从而减低滤波器的带外抑制能力。它限制了测量不等幅信号的分辨率。

频谱仪的分辨率由最窄的中频滤波器带宽确定。譬如，最窄的中频滤波器是10kHz的话，则任何2个能被而且始终被分隔开的是相距10kHz的信号。这是由于频谱仪扫出的就是它自己中频滤波器的波形，就像一个载频扫过中频滤波器时所得。由于频谱仪的分辨率受带宽限制，看起来无限度减小中频带宽就可得到无限好的分辨率。但是实际上可用的中频带宽是受频谱仪稳定度（剩余调频）限制的。若频谱仪的剩余调频是10kHz，则能够用来读出一个单输入信号的最窄中频带宽也是10kHz。任何更窄的中频滤波器将会造成比1根多的响应或间或失掉响应 (单一频率输入时)。还有属于中频滤波器带宽的实用限制性，因为更窄的滤波器有更长的时间常数从而要求更慢的扫描。

灵敏度

灵敏度是度量检出小信号的能力。频谱仪的最高灵敏度由内部噪声限制。噪声基本上可分为二类：热（或江森）噪声和非热噪声。热噪声功率表达如：

$$P_n = K \cdot T \cdot B$$

式中：

P_n = 噪声功率（W）

K = 玻尔兹曼常数（1.38×10^{-23}焦耳/K）

T = 绝对温度，K

B = 系统带宽（Hz）

从上面方程可知，噪声电平直接比例于带宽。所以，带宽减小10倍，噪声降10dB，灵敏度提高10dB。非热噪声是频谱仪内所有不是热所产生的噪声。由于有源元件的非线性，阻抗不匹配等等造成的寄生发射等都属非热噪声。噪声系数，作为非热噪声的度量，与热噪声相加，给出频谱仪系统的总噪声。这系统噪声在示波管上显示出来，确定了频谱仪的最高灵敏度。由于噪声电平是随带宽而变的，所以在评估两台频谱仪的灵敏度时要用同样的带宽。一台频谱仪的扫频在宽的频率范围，但它是一台窄通带仪器。所有在频谱仪频率范围内出现的信号都变换到一个单信号，它必须经过中频滤波器；但是检波器任何时候都看到噪声，所以，频谱仪显示的噪声都包括在中频带宽之内。当测量离散信号时，最大的灵敏度得自最窄的中频带宽。

视频滤波器

测量与频谱仪平均噪声电平大致相同幅度的小信号时要使用视频滤波器。视频滤波器是去到偏转之前的低通滤波器，它把频谱的内噪声加以平均。此时输入信号即可看到。若对于扫频宽度来说，使用很窄的分辨率带宽时，不要用视频滤波器，因为由于视频通带的性质它阻止了被分析信号的幅度达到它的满值。

频谱仪灵敏度

表示一台频谱分析仪的灵敏度可有多种形式。一种是指信号幅度电平，此电平的功率 = 平均噪声功率。频谱仪经常测量信号加噪声。所以，当输入信号等于内部噪声电平时，信号将高出噪声3dB。当信号功率加到平均噪声功率时，示波管上的功率电平是加倍了（增加3dB），由于信号功率 = 平均噪声功率。

频谱仪的最大输入电平是输入电路的损坏电平或烧坏电平。对AT5000系列频谱仪而言此电平到输入混频器为+10dBm和到输入衰减器为 + 20dBm。在未到这个频谱仪损坏电平的功率条件时，频谱仪开始对输入信号增益压缩，直到达到1dB压缩。这个增益压缩不考虑是严重的。最大的输入信号电平它产生结果小于1dB增益压缩时称作是线性输入电平。信号高出1dB增益压缩点时，频谱仪示波管上显示的信号幅度不再精确代表输入信号电平，此时频谱仪认为是工作在非线性状态。

当一个信号输入到频谱仪时，在频谱仪内会产生失真。最多情况是由于输入混频器的非线性特性造成。对AT5000系列频谱仪来说,当输入信号电平送到第1混频器的输入处不超出 – 27dBm时，这些失真典型值比输入信号低70dB。对更大的输入信号，在输入端与第1混频器之间插入衰减器。在保持内部产生的失真低于某个电平，在各衰减器接入而能加上的最大输入信号，称为频谱仪的最佳输入电平。信号在到达第1混频器前经过的衰减器，使到达混频器的信号不超出–27dBm, 否则频谱失真的产物可超出指标所列的70dB范围。这个70dB无失真范围被称为频谱仪的无寄生动态范围。显示动态范围定义为无频谱失真出现时能够在显示屏幕上同时看到的最大信号和最小信号之比。

动态范围的使用要求：显示范围必须足够，无寄生或不必要的响应出现，灵敏度必须足够到从显示的幅度范围内消除噪声。

频谱仪的最大动态范围可以从它的指标中算出。首先查阅失真指标。例如，应当是“ – 27dBm加到输入混频器时所有寄生产物低于70dB”。然后，计算出合适的灵敏度。例如，比 – 27dBm低70dB是 – 97dBm。这个电平我们必须检波出，为此灵敏度，对带宽的要求必须很宽，否则将无法用。最后，显示范围应足够。

另一点可注意的是，无寄生的测量范围可以通过降低送到第1混频器的信号电平来达到。影响的仅仅是灵敏度。为保证在屏幕上有最大动态范围，请参考下述要求。

- 最大输入信号不超出频谱仪的最佳输入电平（0dB输入衰减时典型为–27dBm）。

- 最大输入信号到达示波管的顶线 (参考电平线)。

频率响应

频谱仪的频响是指频谱仪在它的频率范围内，幅度的平坦度。若相等幅度的2个输入信号，频率互异，而频谱显示相等的幅度，则输入混频器的变频损耗必须不依赖于频率。若本振电压比起输入信号来太大，则输入混频器的变频损耗将与频率有关，因此系统的频率响应不是直线性的。为了测量精确，频谱仪在它的频率范围内愈平坦响应愈好。平坦度通常限制了幅度精度因为它很难校准。作为频谱仪的第一功能就是比较不同频率的信号电平，频响不好将严重限制了它的使用性。

跟踪发生器

跟踪发生器 (仅对AT5006) 是一个特别的信号源。与频谱仪联用时，跟踪发生器产生一个信号，它的频率精确地跟踪频谱仪的调谐频率。它之所以能精确跟踪是由于它和频谱仪使用同一个压控振荡器（VCO）。在频谱仪的所有扫频模式时它都能跟踪。这样，在全扫频时跟踪发生器输出一个起到停的扫频。而0扫频时输出简单的一个载波。

跟踪发生器信号是由频谱仪的第一本振和跟踪发生器内部的固定频率锁相振荡器经混频器产生。频谱仪／跟踪发生器系统可有2种组态应用：开环式和闭环式。开环应用时，未知信号外加到频谱仪的输入端,而跟踪发生器的输出接去计数器。此组态是为了选择地精确地高灵敏度地测量频率,此时频谱仪应调谐到需要测试的频率而且置于0扫频状态。

在闭环组态时跟踪发生器信号输出到被测量器件,而此器件的输出则接到频谱仪的输入。在此状态时，频谱分析仪/跟踪发生器变成一台自适应的,完整的（源检波和显示）扫频测量系统。内置的电平控制环路，使跟踪发生器的输出在整个频段内电平一致。这种形式的扫频测量系统可测频率响应（幅度对频率），祇是幅度的反射系数和回损。从回损或反射系数，就可算出驻波比SWR。

这个系统不能测量扫频相位和群延迟测量; 然而,它的确可做到其它扫频系统做不到的事情，诸如扫频仪/网络分析仪，扫频仪/频谱仪，或者扫频仪/检波器示波器做不到的事。

精确跟踪意思是每时每刻此发生器的基波频率始终在频谱仪的通带的中心，而发生器谐波，不管在频谱仪内产生或者跟踪发生器本身产生的，都不在频谱仪的通带之内。这样，仅仅跟踪发生器的基波在频谱仪示波管的屏幕上有显示。二次、三次谐波和互调产物都不在频谱仪调谐之内，所以它们都看不到。这样，即使在测量系统组成中产生了这些失真产物，在示波管显示上却被全部地消除。

1dB压缩点电平是按惯例定的，但它并不是就认为是动态范围的上限。另一方面，下限是频谱仪灵敏度，正如我们已知，是与（中频）带宽有关。最窄的可用带宽是受跟踪发生器剩余调频和介于频谱仪调谐频率和跟踪发生器输出信号之间的跟踪漂移，这几方面所限制。

主要性能标准的检验

AT5005/5006系列频谱分析仪

- **结构完整**
  无明显机械损伤和镀覆损坏现象，各类控制件均安装正确，牢固可靠，操作灵活。通电预热一小时后对仪器进行性能检测。
- **检验Y位置定位是否正确**
  调节Y－POS旋纽, 手感上应有明显的定位点，此时噪声端对准在底格线上。**定位点不正确则所有测量幅值无效**。
- **频率读数准确性**
  最大不超出 ± 2%频谱宽度 +100KHz。
- **频率范围检验**
  用信号发生器输出0.15MHz ~500MHz频率信号，屏幕上都应显示出来。
  跟踪信号发生器的频率范围检验：用频率计连接输出端口，输出衰减为零，频宽为零，调节中心频率旋钮，看跟踪信号发生器能否输出0.15MHz ~500MHz频率的信号。
- **参考电平检验**
  250MHz时为+2dB。
  用标准信号发生器输出频率为250MHz，电平为–27dBM的信号到频谱仪。将频谱仪中心频率调节在250MHz, 频宽为2MHz /DIV, 中频宽为400kHz，输入衰减器为零。信号幅度应达到顶格线上。
  检验跟踪信号发生器输出参考电平：用一根同轴电缆将输出与输入连接起来，中心频率为250MHz、频宽为0MHz /DIV、输入衰减器为30dB、输出最大，此时幅度应为顶线下来一小格线上。
- **频率响应 ± 2dB**
  指频谱仪在测量相同电平、不同频率的信号响应。作为频谱仪的第一功能就是比较不同的频率信号电平，**频响不好严重限制了它的使用性**。
- **衰减器检验**
  (0 ~40dB) 4 × 10dB步进、 ± 1dB+2dB (40dB)。
- **剩余响应及抗干扰性**
  在输入端口接上50Ω终端负载，使输入端口短路，屏幕上不应有信号响应。**否则严重影响频谱仪分析小信号的能力**。
  把输入端口接上50Ω终端负载去除，噪声基线不能向上抬起，特别是跟踪源不能对仪器造成影响。在一般室内，屏幕上不应有信号响应。
- **灵敏度的检验**
  灵敏度应优于–95dB。
  用标准信号发生器，输出一个–95dBm的信号，频谱仪中心频率置于该频率点上、中频带宽为20kHz、扫宽为0.1MHz /DIV、视频滤波开。频谱仪应能测量出该信号 。
- **草地电平**
  中频带为400kHz时典型值为15dB，否则仪器灵敏度达不到指标，无法分析更小的信号。

Spectrum Analyzer AT5005/5006

AT5005

- **Frequency Range:** 0.15MHz to 500MHz
- **4 ½Digit Display** *(Center & Marker Frequency, 0.1MHz resolution)*
- **-100 to +13dBm Amplitude Range,** 20KHz, 400KHz and Video-Filter
- **Tracking-Generator** *(AT5006 only)*
- **Frequency range:** 0.15MHz to500MHz
- **Output Voltage:** +1dBm to to 50dBm*(50Ω)*
- **Accessories:** Users Manual, Power Cord 1pcs

Evolution of the original AT5005/AT5006 has led to the new AT5005/5006 Spectrum Analyzer/Tracking Generator which now extends operation over 1GHz *(frequency range 0.15 to 1050MHz)*. Both fine and coarse center frequency controls, combined with a scan width selector provide simple frequency domain measurements from 100kHz/Div. To 100 MHz/Div. Both models include a 4½ digit numeric LED readout that can selectively display either the center or marker frequency. The AT5005 includes a tracking generator. The AT5005/5006 offer the same operation modes as the AT5005/5006.
The instruments are suitable for pre-compliance testing during develop. prior to third party testing. A near-field sniffer probe set, AZ530, can be used to locate cable and PC board emission "hot spots" and evaluate EMC problems at the breadboard and prototype level. The combination of AT5010/5011 with the AZ530 is an excellent solution for RF leakage/radiation detection, CATV/MATV system troubleshooting,cellular telephone/pocket pager test, and EMC diagnostics. There is an optional measurement output for a PC which makes documentation of results easy and affordable with the AO500 lnterface.

Applications

- ATspectrum analyzer can carry out good inspection to the faults of cable system and wireless system including remote control, cordless phone, cable TV and communication equipment, as well as good comparison and analysis to frequency of signals.
- AT5005 spectrum analyzer can test mobile phone, RF circuits, for example, control signal of logic circuit, baseband signal; local oscillator signal of RF circuit, IF signal and transmission signal, It is very quick and accurate to use AT5005 spectrum analyzer to overhaul the fault of mobile phone which can not enter the network, and determine the fault point.
- Electromagnetic Compatible (EMC) Testing: measure the function of harmful electromagnetic wave to be transmitted by various electronic equipments. In addition, it can output AM/FM demodulation signal from socket PHONE, identify the broadcast signal affected by noise. From authorization aspect, it is very effective measurement function for the evaluation and research in advance to carry out the measurement of radioactive noise.
- Widely used for production, development, education and scientific research. True form of signal (such as RF pulse signal) can be observed from ATTEN spectrum analyzer clearly, where figures are expanded by Fourier series, good for apprehend in education and research.

Specifications

- **Frequency range:** 0.15MHz to 500MHz
- **Center frequency display accuracy:** ±100kHz
- **Marker accuracy:** ±*(0.1% span+100kHz)*
- **Frequency display res.:** 100kHz *(4½ digit LED)*
- **Frequency scan width accuracy:** ±10%
- **Frequency stability:** better than 150kHz/hour
- **Resolution:** 400kHz and 20kHz
- **Video-Filter on:** 4kHz
- **Sweep rate:** 43Hz
- **Amplitude range:** -100dBm to +13dBm
- **Screen display range:** 80dB *(10dB/div)*
- **Reference level: -**27dBm to +13dBm *(in 10dB steps)*
- **Reference level accuracy:** ±2dB
- **Average noise level: -**99dBm *(20kHz BW)*
- **Distortion:** < -55dBc: 2nd and 3rd harmonic
  3rd order intermod: -70dBc

(two signals >3MHz apart)
- **Sensitivity:** Better than -90dBm
- **Log scale fidelity:** ±2dB*(without attn.)*
  Ref: 250MHz
- **Input attenuator:** 0 to 40dB (4×10dB steps)
- **Input attenuator accuracy:** ±1dB/10dB step
- **Max. input level:** +10dBm, ±25VDC *(0dB attenuation)* +20dBm *(40dB attenuation)*
- **Frequency scan width:** 100kHz/div. to 100MHz /div.in 1-2-5 steps and 0Hz/div. *(Zero Scan)*

Tracking Generator

- **Output Frequency:** 0.15MHz to 500MHz
- **Output attenuator:** 0 to 40dB *(4×10dB steps)*
- **Output attenuator accuracy:** ±1dB
- **Frequency response:** ±1.5dB
- **Output impedance:** 50Ω *(BNC)*
- **Radio Frequency Interference(RFI):** <20dBc
- **Output level range:** -50dBm to +1dBm
  (in 10dB steps and var.)

General Specifications

- **Display:** 6 inch, 8×10 division graticule
- **Trace rotation:** adjustment from front panel
- **Power:** 220V ± 10%, 50Hz to 60Hz
- **Power consumption:** approx. 20W
- **Operation Ambient:** 0℃ to +40℃
- **Safety:** Grade I (IEC 1010-1)
- **Weight:** approx. 7Kg
- **Dimensions:** 380×285×125 (L*W*H) mm
- **Input impedance:** 50Ω
- **Socket:** BNC
- **Load resistance:** > 8Ω
- **AM/FM demodulation output**

Near Field Sniffer Probes AZ530 (Optional)

（Olny for 1GHz Spectrum Analyzer）

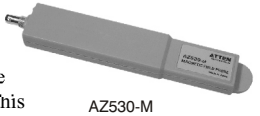
The AZ530 is the ideal toolkit for the investigation of RF electromagnetic fields. Lt is indispensable of EMI pre-compliance testing during product development, prior to third party testing. The set includes 3 hand-held probes with a built-in pre-amplifier covering the frequency range from 100kHz to over 1000MHz.
The probes-ove magnetic field probe, one electric field probe, and one high impedance probe are all matched to the 50Ω inputs of Spectrum analyzers or RF-receivers. The power can be supplied either from batteries, Ni-Cads or through a power cord directly connected to an AT5005/AT5006 series spectrum analyzer.
Signal feedis via a 1.5m BNC-cable. When used in conjuction with a spectrum analyzer or measuring receiver, the probes canbe used to locate and qualify EMI sources, as well as evaluate EMC problems at the breadboard and prototype level. They enable the user to evaluate radiated fields and perform shield effectiveness comparisons. Mechanical screening performance and immunity tests on cables and components are easily performed.

Specifications

- **Frequency range:** 0.1MHz to 1000MHz
  (lower frequency limit depends on probe type)
- **Output impedance:** 50Ω
- **Output connector:** BNC
- **Input capacitance:** 2pF *(high imped Probe)*
- **Max. lnput Level:** +10dBm
  (without destruction)
- **1dB-compression point:** -2dBm
  (frequency range dependent)
- **DC-input voltage:** 20V max
- **Supply Voltage:** 6V DC, 4AA size batteries, Supply-power of Analyzer
- **Supply Current:** 8mA *(H-Field Probe),* 5mA *(E-Fieldprobe),* 24mA *(High imp probe)*
- **Probe Dimensions:** 195×40×19 (L*W*H)mm
- **Housing:** Plastic *(electrically shielded internally)*

The H-Field Near-Field probe

The H-Field probe provides a voltage to the connected measurement system which is proportionalto the magnetic radio frequency (RF) field strength existing at the probe location, With this probe, circuit RF sources may be localized in close proximity of each other.



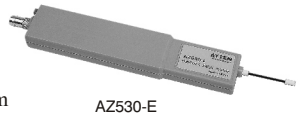
AZ530-M

The H-Field will decrease as the cube of the distance from the source, A doubling of the distance will reduce the H-field by a factor of eight ($H=1/d^3$). where d is the distance.
In the actual use of the H-field sensor one observes therefore a rapid increase of the probe's output voltage as the interference source is approached.

While investigating a circuit board, the sources are immediately obvious. It is easily noticed which compo-nent (i.e.IC)causes interference and which does not. In addition.by use of a spectrum analyzer the maximum a mplitued as a function of frequency is easily identified. Therefore, one can eliminate early in the development components which are not suitable for EMC purposes. The effectiveness of countermeasures can be judged easily. One can investingate shields for "leaking" areas and cables or wires for conducted interference.

The E-Field Monopole Probe

The E-field monopole probe has the highest sensitivity of the three probes. It is sensitive enough to be used as an antenna for radio or TV reception. With this probe the entire radiation from a circuit or an equipment can be measured.



AZ530-E

It is used, for example, for example, to determine the effectiveness of shielding measures. With this probe, the entire effectiveness of filters can be measured by measuring the RFI which is conducted along cables that leave the equipment and may influence the total radiation. In addition, the E-field probe may be used to perform relative measurements for certification tests. This makes it possible to apply remedial suppression measures so that any re-qualification results will be positive. In addition, pre-testing for certification tests may be performed so that no surprises are encountered during the certification tests.

The High-Impedance probe

The High-impedance probe (Hi-Z) permits the determination of the radio frequency interference (RFI) on individual contacts or printed circuit traces. It is a direct-contact probe. The probe is of very high impedance *(near the insulation resistance of the printed circuit material)* and is loading the test point with only 2pF (80Ω at 1GHz). Thereby one can measure directly in a circuit without significantly influencing the relationships in the circuit with the probe. One can, for example, measure the quantitative effectiveness of filters or other or other blocking measures. Individual pins of ICs can be identified. With this Hi-Z probe individual test points of a circuit can be connected to the 50W impedance of spectrum analyzer.

AZ530-H

General Information

The AT5005/5006 spectrum analyzers are easy to operate.The logical arrangement of the controls allows anyone to quickly become familiar with the operation of the instrument, however, experienced users are also advised to read through these instructions so that all functions are understood. Immediately after unpacking, the instrument should be checked for mechanical damage and loose parts in the interior. lf there is transport damage, the supplier must be informed immediately. The instrument must then not be put into operation.

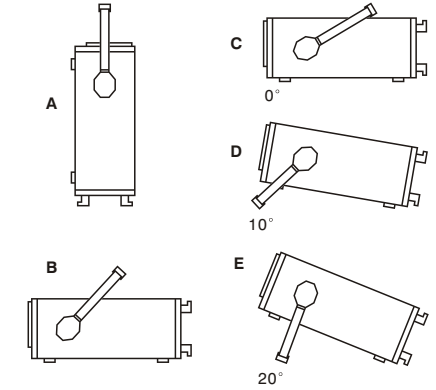
Symbols

ATTENTION - refer to manual

Danger-High voltage

Protective ground (earth) terminal

Tilt handle



To view the screen from the best angle, there are three different positions (C, D, E) for setting up the instrument. If the instrument is set down on the floor after being carried, the handle automatically remains in the upright carrying position (A). In order to place the instrument onto a horizontal surface, the handle should be turned to the upper side of the Spectrum Analyzer (C). For the D position (10° inclination), the handle should be turned to the opposite direction of the carrying position until it locks in place automatically underneath the instrument. For the E position (20° inclination), the handle should be pulled to release it from the D position and swing backwards until if locks once more. The handle may also be set to a position for horizontal carrying by turning it to the upper side to lock in the B position. At the same time, the instrument must be lifted, because otherwise the handle will jump back.

Safety

This instrument has been designed and tested in accordance with ***IEC Publication 1010-1, Safety requirements for electrical equipment for measurement, control, and laboratory use.*** The CENELEC regulations EN 61010-1 correspond to this standard. It has left the factory in a safe condition. This instruction manual contains important information and warnings which have to be followed by the user to ensure safe operation and to retain the Spectrum Analyzer in a safe condition. The case, chassis and all measuring terminals are connected to the protective earth contact of the appliance inlet. The instrument operates according to ***Safety Class I*** *(three-conductor power cord with protective earthing conductor and a plug with earthing contact)*. The mains/line plug shall only be inserted in a socket outlet provided with a protective earth contact. The protective action must not be negated by the use of an extension cord without a protective conductor. The mains/line plug should be inserted before connections are made to measuring circuits. The grounded accessible metal parts *(case, sockets, jacks)* and the mains/line supply contacts *(line/live, neutral)* of the instrument have been tested against insulation breakdown with 2200V DC. Under certain conditions, 50Hz or 60Hz hum voltages can occur in the measuring circuit due to the interconnection with other mains/line powered equipment or instruments. This can be avoided by using an isolation transformer *(Safety Class Ⅱ)* between the mains/line outlet and the power plug of the device being investigated. Most cathode-ray tubes develop X-rays. However, ***the dose equivalent rate falls far below the maximum permissible value of 36pA/kg (0.5mR/h).***

Whenever it is likely that protection has been impaired, the instrument shall be made inoperative and be secured against any unintended operation. The protection is likely to be impaired if, for example, the instrument:

- Shows visible damage.
- Fails to perform the intended measurements.
- Has been subjected to prolonged storage under unfavorable conditions *(e. g. in the open or in moist environments).*
- Has been subject to severe transport stress *(e. G. in poor packaging).*

Operating conditions

The instrument has been designed for indoor use. The permissible ambient temperature range during operation is + 10℃(+50° F)⋯ +40℃ (+104° F). It may occasionally be subjected to temperatures between +10℃ (+50° F) and -10℃ (+14° F) without degrading its safety. The permissible am bient temperature range for storage or transportation is -40℃ (-40° F)⋯ +70℃ (+158° F). The maximum operating altitude is up to 2200m *(non-operating 1500m)*. The maximum relative humidity is up to 80%.

If condensed water exists in the instrument it should be acclimatized before switching on. In some cases *(e.g. extremely cold spectrum analyzer)* two hours should be allowed before the instrument is put into operation. The instrument should be kept in a clean and dry room and must not be operated in explosive, dusty, or moist environments. The spectrum analyzer can be operated in any position, but the convection cooling must not be impaired. For continuous operation the instrument should be used in the horizontal position, preferably tilted upwards, resting the tilt handle.

The specifications stating tolerances are only valid if the instrument has warmed up for 60 minutes at ambient temperature between + 15℃ (+59° F) and +30℃ (+86° F). Values without tolerances are typical for an average instrument.

Warranty

ATTEN warrants to its Customers that the products it manufactures and sells will be free from defects in materials and workmanship for a period of 1 years. This warranty shall not apply to any defect, failure or damage caused by improper use or inadequate maintenance and care. ATTEN shall not be obliged to provide service under this warranty to repair damage resulting from attempts by personnel other than ATTEN representatives to install, repair, service or modify these products.

In order to obtain service under this warranty,

Customers must contact and notify the distributor who has sold the product.

Each instrument is subjected to a quality test with 10 hour burn-in before leaving the production. Practically all early failures are detected by this method. In the case of shipments by post, rail or carrier it is recommended that the original packing is carefully preserved. Transport damages and damage due to gross negligence are not cover by the warranty.

In the case of a complaint, a label should be attached to the housing of the instrument which describes briefly the faults observed. If at the same time the name and telephone number (dialing code and telephone or direct number or department designation) is stated for possible queries, this helps towards speeding up the processing of warranty claims.

Maintenance

Various important properties of the Spectrum Analyzer should be carefully checked at certain intervals. Only in this it largely certain that all signals are displayed with the accuracy on which the technical data are based.
The exterior of the instrument should be cleaned regularly with a dusting brush. Dirt which is difficult to remove on the casing and handle, the plastic and aluminum parts, can be removed with a moistened cloth *(99% water +1% mild detergent).* Spirit or washing benzine *(petroleum ether)* can be used to remove greasy dirt. The screen may be cleaned with water or washing benzene [but not with spirit *(alcohol)* or solvents], it must then be wiped with a dry clean lint-free cloth. Under no circumstances may the cleaning fluid get into the instrument. The use of other cleaning agents can attack the plastic and paint surfaces.

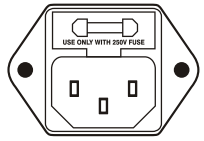
Switching over the mains/line voltage

The spectrum analyzer operates on mains/line voltages of 115V AC and 230V AC. The voltage selection switch is located on the rear of the instrument and displays the selected voltage can be selected using a small screwdriver. Remove the power cable from the power connector prior to making any changes to the voltage setting. The fuses must also be replaced with the appropriate value (see table below) prior to connecting the power cable. Both fuses are externally accessible by removing the fuse cover located above the 3-pole power connector.

The fuseholder can be released by pressing its plastic retainers with the aid of a small screwdriver. The retainers are located on the right and left side of the holder and must be pressed towards the center. The fuse(s) can then be replaced and pressed in until locked on both sides.

Use of patched fuses or short-circuiting of the fuseholder is not permissible; ATTEN assumes no liability whatsoever for any damage caused as a result, and all warranty claims become null and void.

Fuse type



- Size 5×20mm,
- 250-Volt AC,
- Must meet IEC specification 127,
- Sheet lll *(or DIN 41 662 or DIN 41 571, sheet 3)*
- Time characteristic: time-lag

Line voltage: 115V~ ±10% Fuse rating: T315mA
Line voltage: 230V~ ±10% Fuse rating: T160mA

Introduction

The spectrum analyzer permits the detection of spectrum components of electrical signals in the frequency range of 0.15 to 500MHz. The detected signal and its content have to be repetitive. In contrast to an oscilloscope operated in Yt mode, where the amplitude is displayed on the time domain, the spectrum analyzer displays amplitude on the frequency domain (Yf). The individual spectrum components of "a signal" become visible on a spectrum analyzer. The oscilloscope would display the same signal as one resulting waveform.

The spectrum analyzer works according to the triple superhet receiver principle. The signal to be measured *(f_{in}=0.15MHz to 500MHz)* is applied to the 1st mixer it is mixed with the signal of a variable voltage controlled oscillator *(f_{LO} 1350MHz 2350MHz)*. This oscillator is called the 1st LO *(local oscillator)*. The difference between the oscillator and the input frequency *(f_{LO}- f_{in}=1st IF)* is the first intermediate frequency, which passes through a waveband filter tuned to a center frequency of 1350MHz. It then enters an amplifier, and this is followed by two additional mixing stages, oscillators and amplifiers. The second IF is 29.875MHz and the third is 2.75MHz. in the third IF stage, the signal can be selectively transferred through a filter with 400kHz or 20kHz bandwidth before arriving at an AM demodulator. The logarithmic output *(video signal)* is transferred directly, or via a low pass filter to another amplifier. This amplifier output is connected to the Y deflection plates of the CRT.

The X deflection is performed with a ramp generator voltage. This voltage can also be superim-posed on a dc voltage which allows for the control of 1st LO. The spectrum analyzer scans a frequency range depending on the ramp height. This span is determined by the scanwidth ser-ting In ZERO SCAN mode only the direct voltage controls the 1st LO.

The AT5006 also includes a tracking generator. This generator provides sine wave voltages within the frequency range of 0.15 to 500MHz. The tracking generator is determined by the first oscillator *(1st LO)* of the spectrum analyzer section. Spectrum analyzer and tracking generator are frequency synchronized.

Operating Instructions

It is very important to read the paragraph "Safety" including the instructions prior to operating the AT5005/06. No special knowledge is necessary for the operation of the AT5005/06. The straightforward front panel layout and the limitation to basic functions guarantee efficient operation immediately. To ensure optimum operation of the instructions need to be followed.

Attention!

The most sensitive component of the AT 5010/ AT 5011 is the input section of the Spectrum Analyzer. It consists of the signal attenuator and the first mixer. Without input attenuation, the voltage at the input must not exceed +10 dB (0.7 Vrms) AC or ±25 volt DC. With a maximum input attenuation of 40dB the AC voltage must not exceed +20dBm.

These limits must not be exceeded.

otherwise the input attenuator and/or the fist mixer would be destroyed.
When measuring via a LISN (line impedance stabilization network) the input of the Spectrum Analyzer must be protected by means of a transient limiter (Az560)

Prior to examining unidentified signals, the presence of unacceptable high voltages has to be checked. It is also recommended to start measurements with the highest possible attenuation and a maximum frequency range *(500MHz)*. The user should also consider the possibility of excessively high signal amplitudes outside the covered frequency range, although not displayed *(e.g. 1200MHz)*. The frequency range of 0Hz 150KHz is not specified for the AT5005/06 Spectrum Analyzer. Spectral lines within this range would be displayed with incorrect amplitude. A particularly high intensity setting shall be avoided. The way signals are displayed on the spectrum analyzer typically allows for any signal to be recognized easily, even with low intensity.

Due to the frequency conversion principle, a spectral line is visible at 0Hz. It is called If-feedthrough. The line appears when the 1st LO frequency passes the If amplifiers and filters. The level of this spectral line is different in each instrument. A deviation from the full screen does not indicate a malfunctioning instrument.

Control Elements

The front view picture of the instrument *(see last page)* contains numbers referred to below.

(1) Focus
Beam sharpness adjustment.

(2) Intens
Beam intensity adjustment.

(3) Power (Power ON and OFF)
If power is switched to ON position, a beam will be visible on the screen after approximately 10 sec..

(4) TR (Trace Rotation)
In spite of Mumetal-shielding of the CRT, effects of the earth's magnetic field on horizontal trace position cannot be completely avoided. A potentiometer accessible through an opening can be used for correction. Slight pincushion distortion is unavoidable and cannot be corrected.

(5) Marker ON/OFF
When the MARKER pushbutton is set to the OFF position, the CF indicator is field on the horizontal. When the switch is in the ON position, MK is lit and the display shows the center frequency. The marker is shown on the screen as a sharp peak. The marker frequency is adjustable by means of the MARKER knob and can be aligned with a spectral line.

Switch off the marker before taking correct amplitude readings.

(6) CF/MK (Center Frequency/Marker)
The CF LED is lit when the digital display shows the center frequency. The center frequency is the frequency which is displayed in the horizontal center of the CRT. The MK LED is lit when the Marker pushbutton is in the ON position.The digital display shows the marker frequency in that case.

(7) Digital Display (Display of Center Frequency / Marker Frequency)
7-segm. Display with 100kHz resolution.

(8) Uncal
Blinking to this LED indicates incorrectly displayed amplitude values. This is due to scanwidth and filter setting combinations which give to low amplitude readings because the If-filters have not being settled. This may occur when the scanned frequency range *(SCANWIDTH)* is too large compared to the IF bandwidth *(20kHz)*, and/or the video filter bandwidth *(4kHz)*. Measurements in this case can either be taken without a video filter or the scanwidth has to be decreased.

(9) Center frequency-Coarse/Fine
Both rotary knobs are used for center frequency setting. The center frequency is displayed at the horizontal center of the screen.

(10) Bandwidth
Selects between 400kHz and 20kHz IF bandwidth. If a bandwidth of 20kHz is selected, the noise level decreases and the selectivity is improved. Spectral lines which are relatively close together can be distinguished. As the small signal transient response requires a longer time this causes incorrect amplitude values if the scanwidth is set at too wide a frequency span. The UNCAL. LED will indicate this condition.

(11) Video Filter
The video filter may be used to reduce noise on the screen. It enables small level spectral lines to become visible which normally would be within or just above the medium noise level. The filter bandwidth is 4kHz.

(12) Y-Position
Control for adjusting the vertical beam position.

(13) Input
The BNC 50Ω input of the Spectrum Analyzer. Without input attenuation the maximum permissi-ble input voltages of ±25V DC and +10dBm AC must not be exceeded. With the maximum input attenuation of 40dB the maximum input voltage is +20dBm.
The maximum dynamic range of the instrument is 70dB. Higher input voltages exceeding the reference level cause signal compression and intermodulation. Those effects will lead to errone-ous displays. If the input level exceeds the reference level, the input level attenuation must be increased.

(14) Attenuator

The Input Attenuator consists of four 10dB attenuators, reducing the signal height before nter-ing the 1st mixer. Each attenuator is active if the push button is depressed. The correlation of selected attenuation, reference level, and baseline level *(noise level)* is according to the following listing:

Attenuation	Reference level		Base line
0dB	– 27dBm	10mV	– 107dBm
10dB	– 17dBm	31.6mV	– 97dBm
20dB	– 7dBm	0.1V	– 87dBm
30dB	+ 3dBm	316mV	– 77dBm
40dB	+ 13dBm	1V	– 67dBm

The reference level is represented by the upper horizontal graticule line. The lowest horizontal graticule line indicates the baseline. The vertical graticule is subdivided in 10dB steps. As previously pointed out, the maximum permissible input voltages may not be exceeded. This is extremely important because it is possible that the Spectrum Analyzer will only show a partial spectrum of currently applied signals. Consequently, input signals might be applied with excessive levels outside the displayed frequency range leading to the destruction of the input attenuator and/or the 1st mixing stage. Also refer to INPUT.
The highest attenuation *(4×10dB)* and the highest usable frequency range *(scan width setting 50MHz/DIV.)* should be selected prior to any spectral to the AT5005/06 input. This permits the detection of any spectral lines which are within the maximum measurable and displayable frequency range if the center frequency is set to 250MHz. If the baseline tends to move upwards up wards when the attenuation is decreased, it may indicate spectral lines outside the maximum displayable frequency range *(i.e.1200MHz)* with excessive amplitude.

(15) Scanwidth ＜＞ (Push buttons)

The SCAN WIDTH selectors allow to control the scanwidth per division of the horizontal axis. The frequency/Div. can be increased by means of the ＞button, and decreased by means of the ＜button. Switching is accomplished in 1-2-5 steps from 100kHz/div.to 500kHz/div. The width of the scan range is displayed in MHz/div. and refers to each horizontal division on the graticule. The center frequency is indicated by the vertical graticule line at middle of the horizontal axis. If the center frequency and the scan width settings are correct, the X axis has a length of 10 divisions. On scan width settings lower than 100MHz, only a part of the entire frequency range is displayed. When SCAN WIDTH is set to 100MHz/div. and if center frequency is set to 500MHz, the displayed frequency range extends to the right by 50MHz per division, ending at 500MHz [250MHz+(5×500MHz)]. The frequency decreases to decreases to the left in a similar way. In this case the left graticule line corresponds to 0Hz. With these settings, a spectral line is visible which is referred to as “Zero Frequency”. It is the 1st LO (oscillator) which becomes visible when its frequency passes the first IF filter, This occurs when the center frequency is low relative to the scan width range selected. The "Zero Frequency" is different in level in every instrument and therefore cannot be used as a reference level. Spectral lines displayed left of the "Zero Frequency Point" are so-called image frequencies.In the ZERO SCAN mode the Spectrum Analyzer operates like Spectral line(s) passing the IF filter cause a level display *(selective voltmeter function)*.
The selected scan width/div. settings are indicated by a number of LEDs above the range setting push buttons.

(16) X-POS. (X-position)

(17) X-AMPL. (X-amplitude)

Important:

These controls are only necessary when calibrating the instrument. They do not require adjustment under normal operating conditions. A very accurate RF Generator (e.g. ATTENAT8133) is necessary if any adjustment of these controls is required.

(18) Phone

(3.5mm earphone connector)
An earphone or loudspeaker with an impedance ＞16W can be connected to this output. When tuning the Spectrum Analyzer to a spectral line possibly available audio signals can be detected. The signal is provided by an AM-Demodulator in the IF-section. It demodulates any available AM-Signal an provides as well one-side FM-Demodulation. The output is short circuit proof.

(19) Volume

Volume setting for earphone output.

(20) Probe Power

The output provides a +6Vdc voltage for the operation of an AZ530 near field sniffer probe.It is only provided for this purpose and requires a special cable which is shipped along with the AZ530 probe set.

(21) Level *(AT5006only)*

The output level of the Tracking can be continuously adjusted with this knob by 11dBm *(-10dB to +1dBm)*.

(22) TRACK. GEN . *(AT5006 only)*

The Tracking Generator is activated if the push button is depressed (ON). In this case, a sine signal can be obtained from the OUTPUT BNC socket with a frequency determined by the Spectrum Analyzer. In ZERO SCAN mode the Center Frequency appears at the output.

(23) Output *(AT5006only)*

50Ω BNC socket of the Tracking Generator. The output level can be determined from +1dBm to -50dBm.

(24) attention *(AT5006 only)*

Output level attenuator with four 10dB attenuators which allows the signal to be reduced prior to reaching the OUTPUT socket.
All four attenuators are equal and can be activated by pressing the respective push button. Therefore, it is irrelevant which attenuators are used to reach e.g.a 20dB attenuation.

Vertical Calibration

Ensure all input attenuators in released position before calibration. When the signal amplitude reaches to the highest level-line, the signal amplitude is -27dBm, and it will reduce 10dBm for each division drop. If the 40dB attenuator in the spectrum analyzer is completely pressed down, the highest level amplitude will be +13dBm (-27dBm+40dBm).

Prior to calibration, ensure that all input attenuators (14) are released. The AT5005/06 must be in operation for at least 60 minutes prior to calibration. Switch VIDEO FILTER (11) to OFF position, set BANDWIDTH (10) to 400kHz, and SCAN WIDTH (15) to 2MHz/div.

Connect RF signal of -27dBm ±0.2dB (10mV) to the spectrum analyzer input (13). The frequency of this signal should be between 2MHz and 250MHz. Set the center frequency to the signal frequency.

A: A single spectral line (-27dBm) appears on the screen. The spectral line maximum is now adjusted with the Y-POS. control (12) and placed at the top graticule line of the screen. All input attenuators switches have to be released.
The following adjustment is only necessary for service purposes and if the check of this setting shows deviations of the correct settings. The Y-ampl. Control is located on the XY-PCB inside the instrument. In case any adjustment of the vertical amplification is necessary, please refer to the service manual.

B: Next, the generator signal must be switched back and forth between -27dBm and -77dBm, and the Y-AMPL. Control adjusted so that thespectral line peak changes by 5 divisions in the vertical direction. If this results in a change of the Y-position, the calibration outlined under A and B have to be repeated until an ideal adjustment is achieved. Finally, the operation of the input attenuators (14) can be tested at a level of -27dBm. The spec-tral line visible on the screen can be reduced in 4 steps of 10dB each by activating the attenuators incorporated in the spectrum analyzer. Each 10dB step corresponds to one graticule division on the screen. The tolerance may not exceed ±1dB in all attenuation positions.

Horizontal Calibration

Prior to calibration ensure that all input attenuator switches (14) are released. The AT5005/06 must be operated for at least 60 minutes prior to calibration. The VIDEO FILTER push button (11) must be in OFF position, the BANDWIDTH (10) must be set to 400kHz, and SCAN WIDTH (15) set to 100kHz/div. After the center frequency is set to 250MHz, a generator signal must be applied to the input. The output level should level should be between 40 and 50 dB above the noise.

C: Set generator frequency to 500MHz. Adjust the peak of the 500MHz spectral line to the horizontal screen center using the X-POS. control (16).

D: Set the generator frequency to 100MHz. If the 100MHz spectral line is not on the 2nd. graticule line fromleft, it should be aligned using the X-AMPL. Control (17). Then the calibration as de-scribed under be verified and corrected if necessary. The calibrations C and D should be repeated until optimum adjustment is achieved.

Introduction to Spectrum Analysis

The analysis of electrical signals is a fundamental problem for many engineers and scientists. Even if the immediate problem is not electrical, the basic parameters of interest are often changed into electrical signals by means of transducers. The rewards for transforming physical parameters to electrical signals are great, as many instruments are available for the analysis of electrical signals in the time and frequency domains.

The traditional way of observing electrical signals is to view them in the time domain using an oscilloscope. The time domain is used to recover relative timing and phase information which is needed to characterize electric circuit behavior. However, not all circuits can be uniquely characterzed from just time domain information. Circuit elements such as amplifiers, oscillators, mixers, modulators, detectors and filters are best characterized by their frequency response information. This frequency informat5ion is best obtained by viewing electrical signals in the frequency domain. To display the frequency domain requires a device that can discriminate between frequencies while measuring the power level at each. One instrument which displays the frequency domain is the spectrum analyzer. It graphically displays voltage or power as a function of frequency only on a CRT *(cathode ray tube).*

In the time domain, frequency components of a signal are seen summed together. In the frequency domain, complex signals *(i.e. signals composed of more than one frequency)* are separated into their frequency components, and the power level at each frequency is displayed. The frequency domain is a graphical representation of signal amplitude as a function of frequency. The frequency domain contains information not found in the time domain and therefore, the spectrum analyzer has certain advantages compared with an oscilloscope.

The analyzer is more sensitive to low level distortion than a scope. Sine waves may look in the time domain, but in the frequency domain, harmonic distortion can be seen. The sensitivity and wide

dynamic range of the spectrum analyzer is useful for measuring low-level modulation. It can be used to measure AM, FM and pulsed RF. The analyzer can be used to measure carrier frequency, modulation frequency, modulation level, and modulation distortion. Frequency con-version devices can be easily characterized. Such parameters as conversion loss, isolation, and distortion are readily determined from the display.

The spectrum analyzer can be used to measure long and short term stability. Parameters such as noise sidebands on an oscillator, residual FM of a source and frequency drift during warm-up can be measured using the spectrum analyzer's calibrated scans. The swept frequency responses of a filter or amplifier are examples of swept frequency measurements possible with a spectrum analyzer. These measurements are simplified by using a tracking generator.

Types of Spectrum Analyzers

There are two basic types of spectrum analyzers, swept-tuned and real-time analyzers. The swept-tuned analyzers are tuned by electrically sweeping them over their frequency range. Therefore, the frequency components of a spectrum are sampled sequentially in time. This enables periodic and random signals to be displayed, but makes it impossible to display transient responses. Real-time analyzers, on the other hand, simultaneously display the amplitude of all signals in the frequency range of the analyzer; hence the name real-time. This preserves the time dependency between signals which permits phase information to be displayed. Real-time analyzers are capable of displaying transient responses as well as periodic and random signals.

The swept-tuned analyzers of the trf *(tuned radio frequency)* or superheterodyne type. A trf analyzer consists of a bandpass filter whose center frequency is tunable over a desired frequency range, a detector to produce vertical deflection on a CRT, and a horizontal scan generator used to synchronize the tuned frequency to the CRT horizontal deflection. It is a simple, inexpensive analyzer with wide frequency coverage, but lacks resolution and sensitivity. Because trf analyzers have a swept filter they are limited in sweep width depending on the frequency range *(usually one decade or less)*. The resolution is determined by the filter bandwidth, and since tunable filters don't usually have constant bandwith, is dependent on frequency.

The most common type of spectrum analyzer differs from the trf spectrum analyzers in that the spectrum is swept through a fixed bandpass filter instead of sweeping the filter through the spectrum. The analyzer is swept through a narrowband receiver which is electronically tuned in frequency by applying a saw-tooth voltage to the frequency control element of a voltage tuned local oscillator. This same saw-tooth voltage is simultaneously applied to the horizontal deflection plates of the CRT. The output from the receiver is synchronously applied to the vertical deflection plates of the CRT and a plot of amplitude versus frequency is displayed.

The analyzer is tuned through its frequency range by varying the voltage on the LO *(local oscillator)*. The LO frequency is mixed with the input signal to produce an IF *(intermediate frequency)* which can be detected and displayed. and displayed. When the frequency difference between the input signal and the LO frequency is equal to the IF frequency, then there is a response on the analyzer. The advantages of the superheterodyne technique are considerable. It obtains high sensitivity through the use of IF amplifiers, and many decades in frequency can be tuned.

Also, the resolution can be varied by changing the bandwidth of the IF filters. However, the superheterodyne analyzer is not real-time and sweep rates must be consistent with the IF filter time constant. A peak at the left edge of the CRT is sometimes called the "zero frequency indicator" or "local oscillator feedthrough". It occuts when the analyzer is tuned to zero frequency, and the local oscillator passes directly through IF creating a peak on the CRT even when no input signal is present. *(For zero frequency tuning, FLO=FIF)*. This effectively limits the lower tuning limit.

Spectrum Analyzer Requirements

To accurately display the frequency and amplitude of a signal on a spectrum analyzer, the analyzer itself must be properly calibrated. A spectrum analyzer properly designed for accurate frequency and amplitude measurements has to satisfy many requirements:

- Wide tuning range
- Wide frequency display range
- Stability
- Resolution
- Flat frequency response
- High sensitivity
- Low internal distortion

Frequency Measurements

The frequency scale can be scanned in three different modes full, per division, and zero scan The full scan mode is used to locate signals because the widest frequency ranges are displayed in this mode. *(Not all spectrum analyzers offer this mode)*. The per division mode is used to zoom-in on a particular signal. In per division, the center frequency of the display is set by the Tuning control and the scale factor is set by the Frequency Span or Scan Width control. In the zero scan mode, the analyzer acts as a fixed-tuned receiver with selectable bandwidths.

Absolute frequency measurements are usually made from the spectrum analyzer tuning dial. Relative frequency measurements require a linear frequency scan. By measuring the relative separation of two signals on the display, the display, the frequency difference can be determined.

It is important that the spectrum analyzer be more stable than the signals being measured. The stability of the analyzer depends on the frequency stability of its local oscillators. Stability is usually characterized as either short term or long term. Residual FM is a measure of the short term stability which is usually specified in Hz peak-to-peak. Short term stability is also characterized by noise sidebands which are a measure of the analyzers spectral purity. Noise sidebands are specified in terms of dB down and Hz away from a carrier in a specific bandwidth. Long term stability is characterized by the frequency drift of the analyzers Los. Frequency drift is a measure of how much the frequency changes during a specified time *(i.e., Hz/hr)*

Resolution

Before the frequency of a signal can be measured on a spectrum analyzer it must first be re-solved. Resolving a signal means distinguishing it from its nearest neighbors. The resolution of a spectrum analyzer is determined by its IF bandwidth. The IF bandwidth is usually the 3dB bandwidth of the IF filter. The ratio of the 60dB bandwidth *(in Hz)* to the 3dB bandwidth *(in Hz)* is known as the shape factor of the filter. The smaller the shape factor, the greater is the analyzer's capability to resolve closely spaced signals of unequal amplitude. If the shape factor of a filter is 15:1, then two signals whose amplitudes differ by 60dB must differ in frequency by 7.5 time the IF bandwidth before they can be distinguished separately. Otherwise, they will appear as one signal on the spectrum analyzer display.

The ability of a spectrum analyzer to resolve closely spaced signals of unequal amplitude is not a function of the IF filter shape factor only. Noise sidebands can also reduce the resolution. They appear above the skirt of the IF filter and reduce the offband rejection of the filter. This limits the resolution when measuring signals of unequal amplitude.

The resolution of the spectrum analyzer is limited by its narrowest IF bandwidth. For example, if the narrowest bandwidth is 10kHz then the nearest any two signals can be and still be resolved is 10kHz. This is because the analyzer traces out its own IF band-pass shape as it sweeps through a CW signal. Since the resolution of the analyzer is limited by bandwidth, it seems that by reducing the IF bandwidth infinitely, infinite resolution will be achieved. The fallacy here is that the usable IF bandwidth is limited by the stability *(residual Fm)* of the analyzer. If the internal frequency deviation of the analyzer is 10kHz, then the narrowest bandwidth that can be used to distinguish a single input signal is 10kHz. Any narrower IF-filter will result in more than one response or an intermittent response for a single input frequency. A practical limitation exists on the IF bandwidth as well, since narrow filters have ling time constants and would require excessive scan time.

Sensitivity

Sensitivity is a measure of the analyzer's ability to detect small signals. The maximum sensitivity of an analyzer is limited by its internally generated noise. The noise is basically of two types: thermal *(or Johnson)* and nonthermal noise. Thermal noise power can be expressed as:

$$P_n = K \cdot T \cdot B$$

Where:

P_n = Noise power in watts
K = Boltzmanns Constant $(1.38 \times 10^{-23}$ *Joule/K)*
T = absolute temperature, K
B = bandwidth of system in Hertz

As seen from this equation, the noise level is directly proportional to bandwidth. Therefore, a decade decrease in bandwidth results in a 10dB decrease in noise level and consequently 10dB better sensitivity. Nonthermal noise accounts for all noise produced within the analyzer that is not temperature dependent. Spurious emissions due to nonlinearities of active elements, impedance mismatch, etc. are sources of nonthermal noise. A figure of merit, or noise figure, is usually assigned to this ninthermal noise which when added to the thermal noise gives the total noise of the analyzer system. This system noise which is measured on the CRT, determines the maximum sensitivity of the spectrum analyzer. Because noise level changes with bandwidth it is important, when comparing the sensitivity of two analyzers, to compare sensitivity specifications for equal bandwidths. A spectrum analyzer sweeps over a wide frequency range, but is really a narrow band instrument. All of the signals that appear in the frequency range of the analyzer are converted to a single IF frequency which must pass through an IF filter; the detector sees only this noise at any time. Therefore, the noise displayed on the analyzer is only that which is contained in the IF passband. When measuring discrete signals, maximum sensitivity is obtained by using the narrowest IF bandwidth.

Video Filtering

Measuring small signals can be difficult when they are approximately the same amplitude as the average internal noise level of the analyzer. To facilitate the measurement, it is best to use video filtering. A video filter is a post-detection low pass filter which averages the internal noise of the analyzer. When the noise is averaged, the input signal may be seen. If the resolution bandwidth is very narrow for the span, the span, the video filter should no be selected, as this will not allow the amplitude of the analyzed signals to reach full amplitude due to its video bandwidth limiting property.

Spectrum Analyzer Sensitivity

Specifying sensitivity on a spectrum analyzer is somewhat arbitrary. One way of specifying sensitivity is to define it as the signal level when signal power = average noise power. The analyzer always measures signal plus noise. Therefore, when the input signal is equal to the internal noise level, the signal will appear 3dB above the noise. When the signal power is added to the average noise power, the power level on the CRT is doubled *(increased by 3dB)* because the signal power=average noise power.

The maximum input level to the spectrum analyzer is the damage level or burn-out level of the input circuit. This is *(for the AT5005/06)* +10dB for the input mixer and +20dB for the input attenuator. Before reaching the damage level of the analyzer, the analyzer will begin to gain compress the input signal. This gain compression is not considered serious until it reaches 1dB. The maximum input signal level which will always result in less than 1dB gain compression is called the linear input level. Above 1dB gain compression the analyzer is considered to be operating nonlinearly because the signal amplitude displayed in the CRT is not an accurate measure of the input signal level.

Whenever a signal is applied to the input of the analyzer, distortions are produced within the analyzer itselt. Most of these are caused by the non-linear behavior of the input mixer. For the

AT5005/06 these distortions are typically 70dB below the input signal level for signal levels not exceeding -27dBm at the input of the first mixer. To accommodate larger input signal levels, an attenuator is placed in the input circuit before the first mixer. The largest input signal that can be applied, at each setting of the input attenuator, while maintaining the internally generated distortions below a certain level, is called the optimum input level of the analyzer. The signal is attenuated before the first mixer because the input to the mixer must not exceed -27dB, or the analyzer distortion products may exceed the specified 70dB range. This 70dB distortion-free range is called the spurious-free dynamic range of the analyzer. The display dynamic range is defined as the ratio of the largest signal to the smallest signal that can be displayed simultaneously with no analyzer distortions present.

Dynamic range requires several things then. The display range must be adequate, no spurious or unidentified response can occur, and the sensitivity must be sufficient to eliminate noise from the displayed amplitude range.

The maximum dynamic range for a spectrum analyzer can be easily determined from its specifications. First check the distortion spec. For example, this might be "all spurious products 70dB down for -27dBm at the input mixer". Then, determine that adequate sensitivity exists. For example, 70dB down from -27dBm is -97dB. This is the level we must be able to detect, and the bandwidth required for this sensitivity must not be too narrow or it will be useless. Last, the display range must be adequate.

Notice that the spurious-free measurement range can be extended by reducing the level at the input mixer. The only limitation, then, is sensitivity. To ensure a maximum dynamic range on the CRT display, check to see that the following requirements are satisfied.

- The largest input signal does not exceed the optimum input level of the analyzer *(typically -27dBm with 0dB input attenuation)*.
- The peak of the largest input signal rests at the top of the top of the CRT display *(reference level)*.

Frequency Response

The frequency response of an analyzer is the amplitude linearity of the analyzer over its frequency range. If a spectrum analyzer is to display equal amplitudes for input signals of equal amplitude, independent of frequency, then the conversion *(power)* loss of the input mixer must not depend on frequency. If the voltage from the LO is too large compared to the input signal voltage then the conversion loss of the input mixer is frequency dependent and the frequency response of the system is nonlinear. For accurate amplitude measurements, a spectrum analyzer should be as flat as possible over its frequency range. Flatness is usually the limiting factor in amplitude accuracy since its extremely difficult to calibrate out. And, since the primary function of the spectrum analyzer is to compare signal levels at different frequencies, a lack of flatness can seriously limit its usefulness.

Tracking Generators

The tracking generator *(AT5005 only)* is a special signal source whose RF output frequency tracks *(follows)* some other signal beyond the tracking generator itself. In conjunction with the spectrum analyzer, the tracking generator produces a signal whose frequency precisely tracks the spectrum analyzers tuning. The tracking generator frequency precisely tracks the spectrum analyzer tuning since both are effectively tuned by the same VTO. This precision tracking exists in all analyzer scan modes. Thus, in full scan, the tracking generator output is a start-stop sweep, in zero scan the output is simply a CW signal.

The tracking generator signal is generated by synthesizing and mixing two oscillators. One oscillator is part of the tracing generator itself, the other oscillator is the spectrum analyzer's 1st LO. the spectrum analyzer/tracking generator system is used in two configurations: open-loop and closed-loop. In the open-loop configuration, unknown external signals are connected to the spectrum analyzer input and the tracking generator output is connected to a counter. This configuration is use for making selective and sensitive precise measurement of frequency, by tuning to the signal and switching to zero scan.

In the closed-loop configuration, the tracking generator signal is fed into the device under test and the output of the device under test is connected to the analyzer input.

In this configuration, the spectrum analyzer/tracking generator becomes a self-contained, complete *(source, detector, and display)* swept frequency measurement system. An internal leveling loop in the tracking generator ensures a leveled output over the entire frequency range. The specific swept measurements that can be made with this system are frequency response (amplitude vs. frequency), magnitude only reflection coefficient, and return loss. From return loss or reflection coefficient, the SWR can be calculated. Swept phase and group delay measurements cannot be made with this system; however, it does make some unique contributions not made by other swept systems, such as a sweeper/network analyzer, a sweeper/spectrum analyzer, or a sweeper/detector oscilloscope.

Precision tracking means a every instant of time the generator fundamental frequency is in the center of the analyzer passband, and all generator harmonics, whether they are generated in the analyzer or are produced in the tracking generator itself, are outside the analyzer passband. Thus only the tracking generator fundamental frequency is displayed on the analyzer's CRT. Second and third order harmonics and intermodulation products are clearly out of the analyzer's CRT. Second and third order harmonics and intermodulation products are clearly out of the analyzer tuning and, therefore, they are not seen. Thus, while these distortion products may exist in the measurement set-up, they are completely eliminated from the CRT display.

The 1dB gain compression level is a point of convenience, but it is nonetheless considered the upper limit of the dynamic range. The lower limit, on the other hand, is dictated by the analyzer sensitivity which, as we know, is bandwidth dependent. The narrowest usable bandwidth in turn is limited by the tracking generator residual FM and any tracking drift between the analyzer tuning and the tracking generator signal.

Mainly Performance and Calibration of AT5005/5006 Series Spectrum Analyzer

1. Structural integrity

No obvious impairment and gilding damage, all outside components are well installation, reliable fasten and flexible operability. Warm up for one hour to inspect the performances.

2. Inspection of Y-POS

Adjust Y-POS knob, occurs hand feeling by obvious locating point. ***Failures in adjusting the locating point will lead to all measured amplitudes are invalid.***

3. Accuracy of frequency readout

Not exceed ± 2% spectrum width +100kHz

4. Inspection of frequency range

Output 0.15MHz 500MHz frequency signal from a signal generator, screen should display the complete signals.

inspect frequency range of tracking signal generator: connect output port with frequency counter, both output attenuation and bandwidth are zero, adjust CF knob, to check the signal generator could output 0.15MHz 500MHz signal or not.

5. Inspection of reference level

±2dB at 250MHz

Output 250MHz frequency and -27dBm level signal, from signal generator to spectrum analyzer. Set spectrum analyzer CF at 250MHz, scanwidth 2MHz/DIV, center frequency 400kHz, with zero input attenuation. And signal amplitude should up to top line.

Inspect the output level of tracking generator: connect input to output with a coaxial cable, with CF250MHz, scanwidth 0MHz/DIV, input attenuation 30dB, maximum output, then amplitude should lower the top line than one graticule.

6. Frequency Response

It means signal response of spectrum analyzer in measuring equal level and different frequency. Since the primary function of the spectrum analyzer is to compare signal levels at different frequencies, ***a lack of flatness can seriously limit its usefulness.***

7. Inspection of attenuators

(0~40dB)4×10dB step, ±1dB/10dB, ±2dB(40dB).

8. Residual response andinterference immunity

Short circuit the input by connect a 50Ω terminal load to input port, then signal response should not appears in screen. ***Otherwise, it may seriously affect the ability of spectrum analyzer in analyzing small signals.***

Replace the 50Ω terminal load off input port, noise base line should not raise, especially the tracking source cannot affect the instrument. In a common room, no signal response appears in screen.

9. Inspection of sensibility

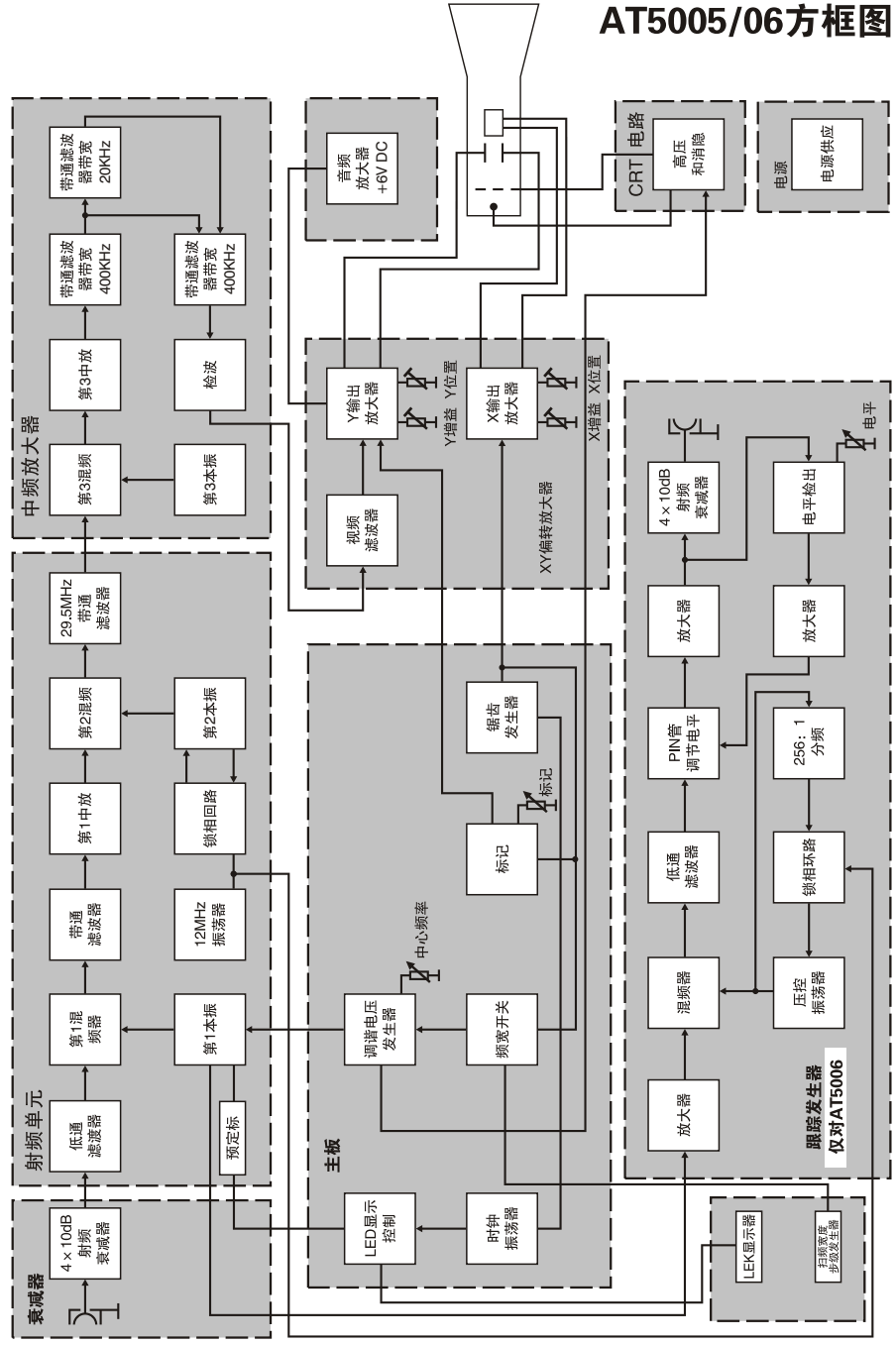
Sensibility should better than -95dB.

Output a -95dBm signal with a standard signal generator, set CF in the frequency, with IF 20kHz, 0.1MHz/DIV scanwidth, video filter on. Spectrum analyzer is able to measure the signal.

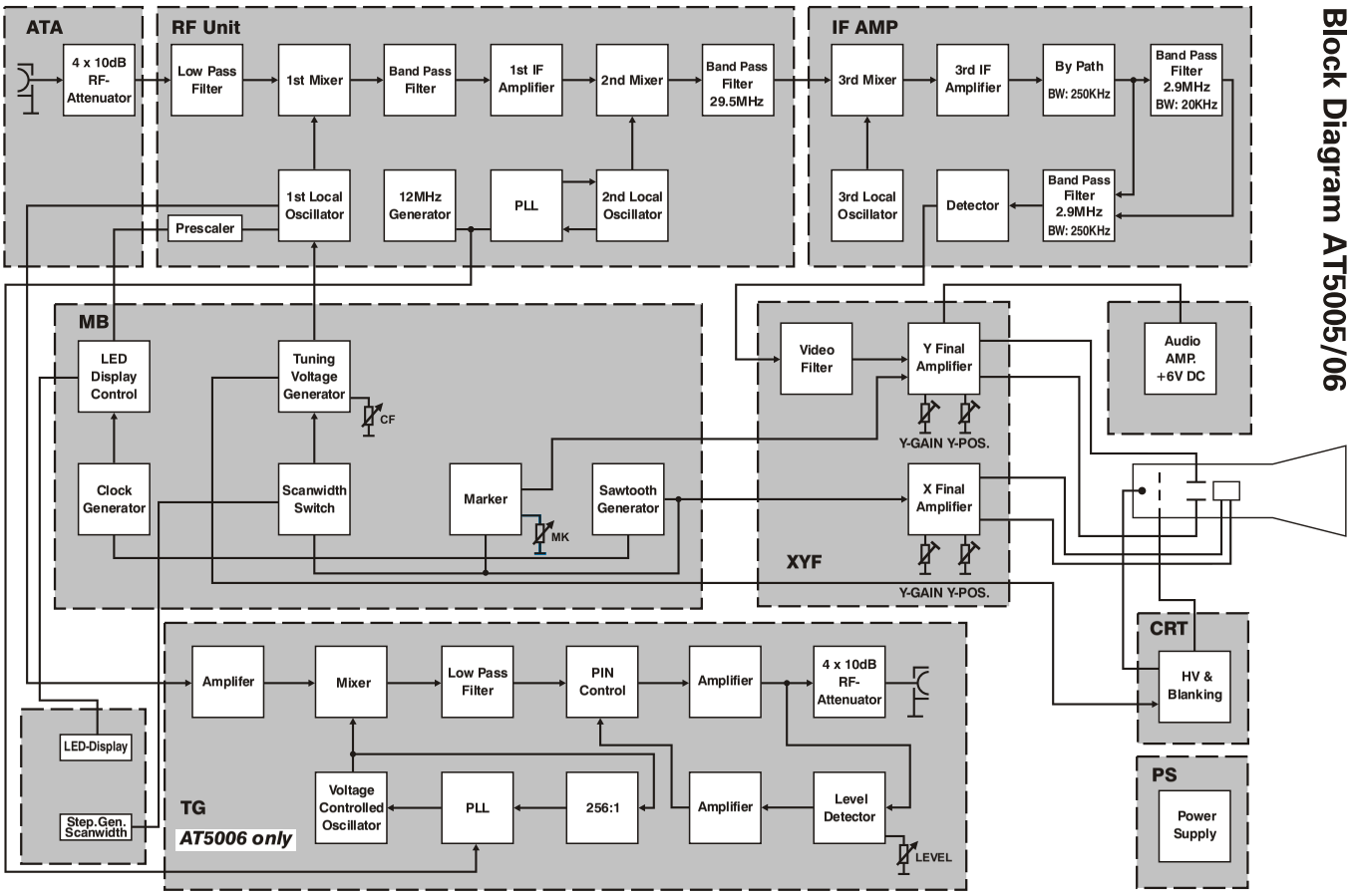
10. Grass level

The typical value is 15dB when IF bandwidth is 400kHz, otherwise, the sensibility of he unit is too inferior to analyze smaller signals.

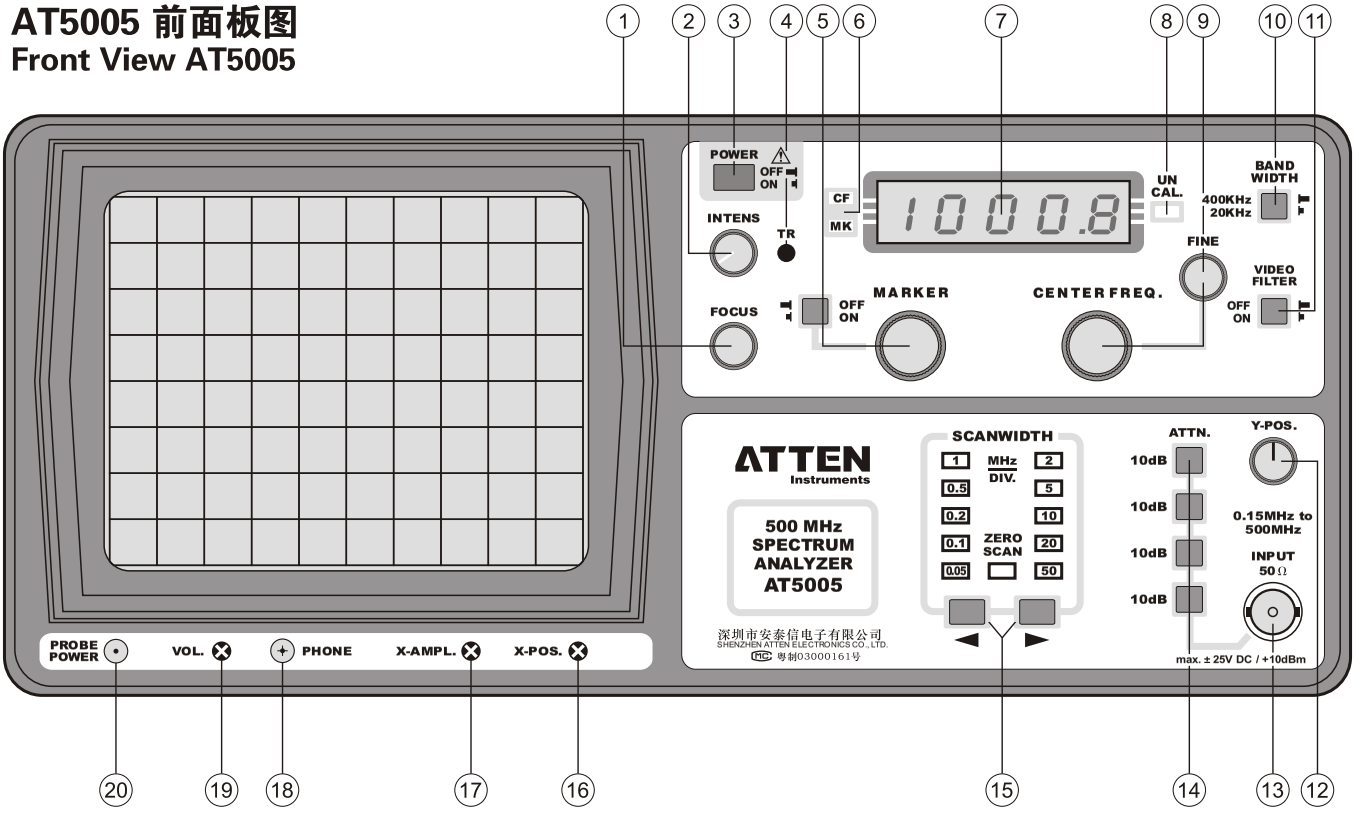
AT5005/06方框图



Block Diagram AT5005/06



AT5005 前面板图
Front View AT5005



AT5006 前面板图
Front View AT5006